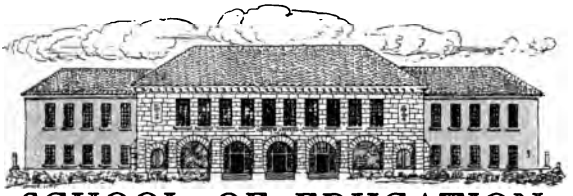

NUMBER WORK

IN

NATURE STUDY

PART I.

BY

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TO THE TEACHER.

The aim of this book, briefly stated, is to show how pupils may be taught to secure, through mathematical processes, definite, accurate, and useful results in the study of elementary science. The work does not contain arithmetical problems, such as may be found usually in the text-books, but it is to be regarded, rather, as a series of formulas which are to be applied in the study of a particular subject, as the common sense and judgment of the teacher may dictate.

The purpose of the book differs so radically from that of the arithmetics used in the schools, it becomes necessary to call the especial attention of the teacher to the discussion of the underlying principles, found in the introductory chapter, and to ask a careful consideration of a few important details of method.

Throughout the work, wherever it is possible, individual investigation on the part of the pupil is presupposed; not an investigation of the subject of number or of numerical processes, but of some phase of nature study. It follows, therefore, that no two pupils will work from exactly the same set of data, though the relations established by the results obtained should be and will be approximately the same. Each pupil should multiply observations and

collect data to the utmost limit of his time and ability, that his final results, upon which his conclusions must rest, may contain, under the conditions which the pupil labored, the minimum amount of error. As a further check upon the individual, a class result, based upon an average of the results obtained by all the members, may be required; this demands the most careful management on the part of the teacher, however, that the self-reliance of the individual pupil may not be weakened and ultimately destroyed.

In arithmetic, as it is usually taught, the attention of both teacher and pupil is fixed upon the *process* involved in the solution of the problem; in this book, the attention of both must be directed to the *result* obtained by the solution. A failure, on the part of the teacher, to observe this fundamental difference will render entirely fruitless any effort made to use this work effectively. With an inventive genius worthy of a better cause, authors of text-books in arithmetic have usually devoted themselves to devising problems apparently in the belief that they are interesting and educative in proportion to the labyrinthine details involved in their solution. Not one in a hundred of such problems has the slightest interest attached to the result, and the teacher, recognizing this, too often excuses mistakes in calculation, saying: "Never mind, you understand *how* the problem is done." A more violent distortion of the function of mathematics in education can not be imagined.

The teacher must aim to place a proper estimate —neither too high nor too low—upon the results

obtained. It may be impossible, for example, for the pupil to find out, by any amount of observation, measurement, and calculation, the *exact* and *whole* truth concerning the relation of summer and winter rains in any particular region. But, in the study of meteorology and geography, it is perfectly possible to so frame a series of problems that *the results will indicate a law* and that *each problem will lead a step nearer to that law.* The measurement of a dozen twigs may not tell much respecting the relative growth from terminal and lateral buds; yet, if there be a law, *that* it is, and *what* it is can be established by such means only, and it merely remains for the pupil to multiply his observations that he may reach the truth. It is ever the suggestion of law that gives intelligence to thought and this, then, is to be the teacher's guide: first, do the results obtained by a solution of the problems, when compared, indicate law; and second, does a multiplication of the problems show what the law is? The questions are given, then, with a definite end in view and, if this be lost sight of, they have absolutely no function whatever.

In choosing problems to be solved, the teacher should select those under that mode of comparison best adapted to the capabilities of the pupils. The genesis of the different modes of comparison is discussed in the introductory chapter. The number and the nature of those to be solved must be determined for each pupil by the necessities of the case. The sole aim, it should be remembered, is to establish in the mind of the pupil a clear and definite concept;

in some instances, two or three problems may suffice, in others, twice as many, or, in some cases, the entire list may be given, to which others may be added. But to require the pupils to solve an entire list in the usual machine-like arithmetic way could hardly be anything, in the vast majority of cases, but the most arrant nonsense. An effort has been made to give such a range and variety of questions that the teacher may find among them those that are adapted to the pupils' needs, from whatever side the study of the subject may be approached. Each problem finds its origin in the necessities and the conditions arising in the process of the development of intrinsic thought and it is, therefore, of fundamental importance that each result be clearly interpreted.

It is intended that the subject matter found in nature study should furnish whatever illustrative material may be necessary in order to develop in the pupil's mind a correct idea of the different arithmetical operations. For example, it is not necessary to develop the processes by which areas and volumes may be found by means of card-board and various solids having no intrinsic worth to the pupil. But, to illustrate, when the subject of evaporation is being studied an opportunity is then offered to develop these processes by the very nature and demand of the study itself. And if the interest of the pupils is genuine, if it is voluntary, not forced, the mastery of the processes involved is an exceedingly simple matter.

The pupils should be provided with every possible facility for making measurements of different kinds rapidly and accurately. Rulers, balances and

weights, pencils and paper should always be ready for instant use. To avoid delays from various causes, a ruler may be screwed down to the top of each desk near one edge, and with a pair of calipers or dividers measurements may be made with great ease. The constant presence of the different units will do much to fix them in the pupil's mind. Balances and suitable weights may be obtained for a trifling outlay, and they should form a part of the apparatus of every school-room. A brass protractor may be screwed against the wall and by this means the pupils may learn to measure angles accurately.

In order to facilitate the distribution of work among a number of pupils, it has been thought better to write out, in nearly every case, each example in full rather than to shorten and combine several under one number. Except where such fractions as halves, thirds, fourths, etc., occur, it is by far easier to use decimals and this is strongly recommended. The ease by which reductions can be made renders it also exceedingly desirable that the metric system should be used throughout. For the purposes of convenient reference, only, a list of the more important tables is given on another page.

The problems are arranged under the different months merely because the line of nature study pursued in the Cook County Normal School makes such grouping convenient. It is expected that teachers, elsewhere, will change the order, if necessary, to better adapt it to their peculiar conditions.

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Cook County Normal School,

Sept. 1, 1893. *Chicago, Illinois.*

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INTRODUCTION.

RELATION OF ARITHMETIC TO ELEMENTARY SCIENCE.

The introduction of elementary science into the grammar and primary grades of the public schools is destined to mark an important epoch in the history of school-teaching in this country. The scope of the work included under the head of natural science is so great that anything like a general introduction of it into the lower grades will necessitate a thorough reorganization of the course as it has long existed and now stands. The greatest problem at this time, therefore, is one of readjustment, and it is not easily solved; for the present course of study, as usually laid down, is fortified not only in the wisdom, but also in the prejudices and traditions of the past. The reorganization will be accomplished partly by a displacement of some of the studies once considered essential, but chiefly by a readjustment of the parts so that the course will form an organic whole.

In this age of doubting and questioning, when the search-light of reason is turned upon every creed and custom, the assurance is that unless a subject

can show a stronger reason for its place than may be found in the homage it has received in the past, it will have to give way. Not much room can be hoped for, however, in this direction, for experience has shown the desirability of retaining in the course the greater part, by far, of all that is now taught. If any new subject, therefore, is to enter the sacred circle of the present curriculum, it must show itself capable of entering into organic relation with most of the subjects already there.

That a full line of science work is soon to be a part of the regular school programme no one can any longer doubt; and the question which must be settled for the teacher, and by the teacher, is, what relation does it bear to the work already being done? The basis upon which the answer must rest is found in the nature of mental action. In mind movement we may logically, if not actually, discern the thought, and the form embodying it or through which it is expressed. All studies, then, naturally fall into two divisions which may be distinguished as *thought* studies and *form* studies. As it is difficult to conceive, much more to define, thought independent of the form through which it is expressed, so it is difficult, if not impossible, to exactly define and precisely distinguish thought studies from form studies. Logically, such a distinction does exist; actually, however, in ideal educational methods it does not. How far we are and have been from such an ideal, the present bootless pursuit of pure form work will testify. Form studies have always been held to be of great value as a means of discipline; thought studies

are those which deal with knowledge that is in itself intrinsic, with knowledge which is of present absolute worth to the possessor independent of the form by which it is gained and retained. Thus one may learn with varying clearness, by means of a model, a drawing, a painting, a written or oral description that alcohol in large quantities is injurious to the membrane lining the stomach. This knowledge is of intrinsic value to the individual, and is the same in kind, though not in degree, by whatever means it has been gained and is retained.

Logically distinguishable from these thought studies—but not actually separated from them—are what may be, for convenience, termed form studies. Form studies include all the different modes of expression: making, modeling, painting, drawing, written language (associated with which are reading and spelling), oral language, form, and number. The relation of form studies to thought seems to be this: external energy, referred to some object as its source, arouses to activity the nerve centers, and the individual then vests this externality—the source of the energy — with color, form, outline, size, weight, density, odor, and all other distinguishable properties, according to the sense or senses through which the energy acts. Thus, from some object, energy of a certain kind reaches a nerve center through the eye; the mind then vests the object—the mediate source of the energy — with color. Again, the object is placed in contact with the finger tips; now the energy, of which the object is the source, reaches a nerve center through the

sense of touch and the mind vests the object with form and density, and so on throughout the entire course of observation. This action of the mind may be guided somewhat by oral or written description, and by a careful comparison with facts already in experience, and thus, the thought gradually becomes a definite product in consciousness. At the same time, as it becomes a more closely approximating mental correspondence to the source of the energy, the thought clears up and becomes definite in consciousness.

It is of the greatest importance that all concepts be formed in the mind with *readiness*, *accuracy*, and *completeness*. The rate of mental development is absolutely determined by these three conditions. The readiness with which concepts are formed depends upon the alertness, the all-sided sensitiveness of the body to all the forms and varieties of energy, which impinge upon it and condition thought. Readiness is dependent primarily and largely upon physical and physiological conditions.

Accuracy in forming concepts depends upon two things: first, upon the power of the mind to distinguish all the different forms and varieties of energy from each other; as, for example, to distinguish colors from sounds, and to discriminate between blue and pink. Second, it depends upon the mind's power to determine the limitations of the energy acting upon it; that is, the mind must not only measure or exactly estimate, in some way, the value of each form of energy in itself, it must also determine its relative value to all other forms with which it is associated,

if the concept is to be clear. Thus, for example, when I look at a box, if I properly apprehend and estimate the energy received by the eye, I get a correct idea of its outline; and in the same way if I properly estimate the energy received when it is placed in contact with my finger tips, I get a correspondingly definite idea of its density and form. This determination of the limitations of the energy is always done through a comparison with a standard measure. Accuracy is dependent upon the power of judging, and therefore upon psychic conditions. It is the absolute necessity for accuracy *that gives rise to the demand for the mathematical element in education.*

The completeness or adequacy of the concept is determined by the power of the mind to grasp and retain the relations which the various forms and varieties of energy bear to each other. This is also dependent upon psychic conditions.

The function of the teacher would seem, therefore, to be purely a directive one; he may create conditions, and, granting that their arrangement is the best possible (though for no two pupils, perhaps, would the arrangement be equally good), he has absolutely nothing beyond a directive power in determining the readiness, accuracy, and completeness with which the pupil shall gain a concept.

The weakest point in all teaching of the present time lies in that part which relates to the *accuracy* of the concept. All teaching must be quantitative, not alone qualitative, using these terms in the laboratory sense; and there is, therefore, a constant and

positive demand for the mathematical element in education. It is the function of the studies of form and number to meet this demand for accuracy, and they can claim a place in the common school curriculum for no other purpose whatever. This classes them, then, from the pedagogical standpoint as *form* studies, as distinguished from *thought* studies, and it is as such that they are here to be treated. That two multiplied by two multiplied by two equals eight is not of the slightest consequence in itself; but when it is said that the box is two feet long, two feet wide, and two feet deep, the value of one's knowledge of the box is greatly increased. And when, still further, it is said that all the angles are right angles and that all the lines are straight lines, the mental correspondence is a close approximation to the truth. Of course, to the educated mind, distance, angles, and lines are matters of experience, and the mere mention of the appropriate terms and units is enough to enable it to clear up the concept of the box. But the case is different in the young and inexperienced, in whose mind the notions of lines and angles and judgments of space and distance are almost totally wanting. The whole question at issue is, shall the attempt be made, first, by means of this, that, and the other ingenious device and by use of objects to which the child is more or less indifferent, to give the child the notions of lines and angles and judgments in number, to create in him a stock in trade which he may use when he finds occasion, or shall these notions be developed to meet the necessities arising from legitimate observation at the moment when the demand is most imperative?

In considering the question, it is interesting and instructive to note that, within the memory of those now living, it was almost universally held that all form studies should be pursued in the beginning for their own sake: first, because of their extraordinary disciplinary value; and second, that the mind might early be provided with a lot of skeletons upon which to build flesh in after life. But there is to-day a considerable number of teachers, and the number is rapidly increasing, who believe that reading, for example, need not be taught except as the necessities of developing thought demand it, and yet, that it may be thus taught well; that to teach spelling it is not necessary to isolate all the words in the language and write them in columns in a separate book to be conned and committed; who believe that enough practice to teach writing, drawing, painting, and modeling will come in the proper use of the material used in connection with legitimate thought work. Some teachers have worked out the problem in one direction and some in another; very few or none have carried out the principle along all lines of form work. Enough has been done, however, to establish the validity of the principle and to show its practicability in connection with all the subjects named. As to tangible results, there has been, perhaps, as much failure as success; but, if there has been success in one instance even, and that, too, only under ideal conditions, the validity of the principle is established, the true ideal is furnished, and all we have to do is to work as best we may toward it. The failures have been wholly due to lack of skill in presenting the

thought, or in the failure on the teacher's part to grasp the real scope of the thought to be presented.

The only subject which has not at this time yielded to the operation of the principle just enunciated is number. Arithmetic—and form also to a less degree—more strongly than any other subject, stands intrenched in the dogmas and traditions of the past. So long has it been enthroned in every schoolhouse, and in the heart of every teacher, as *the* great subject to be taught, it now stands aloof and apart in a state of almost complete isolation. When one looks back over his school-days, no other subject looms up in such proportions as arithmetic. It is the one thing which consumed his time and absorbed his energy. Goaded on by the promise of future reward, we unceasingly and unlovingly toiled. But now, when in later years we stretch out our hands to seize the promised reward, we find it turns to ashes. It is no wonder then that an outraged generation grown to the estate of manhood, should cry out against arithmetic and seek to drive it almost wholly from our schools. And, still further, it is proclaimed that the time spent upon number in the schools is wholly out of proportion to the demand made for its application in after life; that, while little was received, now Heaven be praised, less still is needed; and the conclusion in either case is that the time given to arithmetic, number teaching, must be reduced.

It would be most interesting to stop here and scan the pages of the history of education to find how it is that arithmetic gained the prestige it has so long enjoyed. The reason is clear. The magnificent

achievements in science, through the application of mathematics, of such men as Kepler, Newton, La Place and others, gave to humanity such splendid ideas of the members and forces of this universe, and rendered our knowledge of them so clear and definite, that the world has ever since been awed almost into worship of even the means they employed. Think of the richness which mathematics possessed for such a man as Newton! His every calculation fixed for him a star in the heavens; it set the time and places of the planets, and measured the force which holds them swinging forever in their orbits. By the aid of mathematics, Newton was able, more than any other man from the dawn of creation down to his day, to penetrate the remote recesses of this universe and to read the secrets of the Almighty.

Turn now from the contemplation of such a mind, filled with this orderly array of knowledge gathered from every corner of the universe, to a consideration of the store in our minds. What has our mathematics done for us? Has it opened up, and rendered clear for us, anything in this magnificent world about us? Did the study of mathematics give us any clearer notions of the forces that focus upon us and condition our existence? Did our arithmetic put anything into our lives which gave us a broader and better outlook into nature, and rendered our existence freer from superstition and more neighborly with the truth? In so far as it has failed to do these things, we have been the victims of a mistake in teaching.

That there should be any attempt to decry arithmetic teaching in the schools, brings us face to face

with a desperate situation. Those who believe that they see in the different studies of the common school the necessary and organic elements of a symmetric whole, must push forward to the rescue before some iconoclast rises from the long-suffering public and by some arbitrary act deprives us of the power to organize the reform. Those in the past who gave mathematics its place of honor among studies were driven to the study by their thoughts about the universe. By means of mathematical calculations, their indistinct notions became clear and definite ideas. So should it be with the pupils in the public schools; all thought studies actually demand mathematical work that thought itself may become clear. It is the function of form and number study—that is of the *mathematical element* in education—to give accuracy and exactness to ideas; to render hazy notions clear, and to evolve the definite from the indefinite. The man who says that he can go through any and all walks of life without this mathematical element as safely as he can with it, is most blindly and grossly self-deceived. Nearly all, if not all, the failures of life come to us because at some point in the train of our calculations our ideas were not exact. The reason for our neglect in this direction is that we were not led to see the value of such accuracy in quantitative work when in school. Almost all school exercises are qualitative only; they do not demand *definite* amounts of anything. Despite the fact that arithmetic has in the past, and does now as a rule take far more than its share of programme time, yet it may be safely affirmed that true education in accuracy,

the cultivation of the mathematical powers of the mind, has been and is grossly neglected.

The long isolation of number work from everything else has not only been hurtful to all other subjects thus deprived of its assistance; it has proved to be terribly self-destructive. In trying to preserve itself upon its pedestal of self-conceit and self-sufficiency, it has been driven to most absurd lengths to obtain materials for subject-matter, and it has pressed upon teachers methods of instruction that in many cases are simply senseless. It requires but a passing glance at any arithmetic that one may pick up to see that the subject-matter in arithmetic is as bad or perhaps worse than it ever was in the case of reading, drawing, or writing. It is not an exaggeration to say that at least ninety per cent. of all the exercises given in an average arithmetic fall into one or the other of two classes: first, those which deal wholly with abstract operations, and second, those which deal with material absolutely outside the experience of the pupil. A few examples will illustrate this point. Open any arithmetic and count the weary pages of such problems as "What is $\frac{1}{3}$ of 6? $\frac{2}{3}$ of 9? $4+8=?$ $13-4=?$ $\frac{1}{3}+\frac{1}{8}=?$ $\frac{1}{6}+\frac{1}{7}=?$ $2\frac{2}{3}-\frac{3}{4}=?$" *ad nauseam.* It serves no purpose for the teacher to say that he can create and sustain an interest in such work. Everyone, doubtless, has been very much interested in just such problems; but, if they are of intrinsic value, then why is it that all interest in them is lost the moment the pupil reaches the years of reason and accountability? A subject of intrinsic value never loses its interest. We gain a little from

it when we are young, and that interest deepens and intensifies with age. The truth is, the young mind is so inherently active, it is so ready to grasp everything, that we frequently mistake the buoyancy of its self-activity for genuine interest in the subject in hand.

Turning now to the second class of problems alluded to above, namely, those which deal with material beyond the experience of the pupil, the same dreary waste of pages may be found. It is within the bounds of truth, perhaps, to say that nine-tenths of all the so-called concrete problems found in our arithmetics deal with questions of values. This is a mistake as fundamental as it is singularly perverse and unfortunate, as a little consideration of the subject of values will show. Value is wholly relative, and it grows out of the fact that man is a social being. From the very nature of man's social relations there must arise necessities for exchange among the different members of the community, and thus business relations are established, and, growing immediately out of this is the question of value. Now it is universally conceded that, while adult man willingly subjects himself to the laws which the necessities of his social relations place upon him, the child does not, at once, recognize such obligations. And since his notion of business necessarily develops much later, it follows that his idea of value under ordinary circumstances must be late in maturing. This is merely the statement of a fact with which all are more or less familiar. An average third-grade boy on the south side of a building on a warm spring

day would not exchange his pocketful of marbles for a corner lot unless he saw immediate prospect of reconverting it into marbles again. And yet that same boy through all time has been expected to solve problems relating to the sale of lands and estates with all the ease of a real-estate agent of long experience. They are not much older when they are expected to solve problems relating to banking, taxation, insurance, and stock exchange, the real nature of which they can have absolutely no conception whatever.

It will be maintained, however, that the notion of value must be developed. This is true, but let no one deceive himself by supposing that he is developing the idea of value in his pupils when he is having them solve problems in which incomprehensible values are handled. Nor can the teacher materially hasten the time when the idea of value can be gained. It depends absolutely upon experience, and, therefore, requires time and can come only with age. The value of a dollar is known only when it has been earned. The time is certainly not perceptibly hastened by the early introduction of toy money and imaginary bargain counters. These devices have about as much to do with the notion of developing value in the mind of the pupil as the skin of a stuffed monkey has with developing an idea of the South American fauna. Most of such devices are nothing but the stuffed monkeys of mathematics. This fatal mistake of filling arithmetics with purely abstract problems, and, also, the so-called concrete problems which deal with incomprehensible material, has reduced the

learning of arithmetic on the part of the pupil to the memorizing of a string of disconnected exercises which can neither be remembered nor applied because they are not associated in the mind with any intrinsic thought, and it has driven the instructor to employ a vast multitude of catchpenny devices for the purpose of teaching a few very simple processes. It is one of the greatest monstrosities of modern education that the application of processes so few in number, and so simple as those in arithmetic, should be so little known and so poorly understood by both pupil and teachers.

Just how much number work must go with science work is the question that must now be considered. To be sure, it is too much to say that all mathematics must be *science* mathematics; for every subject which demands accuracy in thought must of necessity furnish mathematical material of some kind; but it is not too much to affirm that all science must be *mathematical* science. Actual advance in science work is not possible without the introduction of the mathematical element of accuracy in quantitative work. The children may observe a great deal, but they will not progress unless they, in the appropriate way, accurately measure as they go. As science work is now done, in most cases, the pupils are getting a great deal of color work and written and spoken language; but they are not getting exact and definite concepts because the mathematical element is almost wholly wanting. They are in the precise condition of one who learns the color and kind of material in a box, but learns nothing of its

exact form, size, or weight. Their written and spoken language, and to some extent their drawings, show this in the great paucity of mathematical terms and in the lack of exact proportion of parts. In speaking or writing they say "few," "many," "some," "about," "nearly," "somewhat," "I think," "I believe," "I should say," etc., all of which expressions and terms indicate a lack of clearness and definiteness of thought. They are seldom confident enough in their work to make a direct and unqualified assertion respecting any observation. This tends to make the observation more lax, and forms in the pupils ruinous habits of carelessness and inexactness.

It is one thing to point out an inherent weakness in any system of instruction, but it is another to suggest a remedy, and usually a much more difficult thing still to apply it. The ability to teach the arithmetic, in connection with any science work, which is necessary to render the outline and details of the experiment or observation clear, presupposes the clearest possible insight on the part of the teacher into the central thought, point, and scope of that experiment or observation. Failing in this depth of insight, the teacher will not feel the demand for number (which is only another way of saying that he sees nothing to number), and all problems will be given at random, and consequently they will not help to clarify and develop that central thought. In order to understand more clearly the relation of number to science work, it is necessary at this point to inquire into the nature of the chief operations in arithmetic.

The mathematics in connection with science work naturally divides itself into two parts. These are, first, what pertains to the collection of accurate data, and second, that which pertains to comparisons necessary in making generalizations. By the collection of accurate data, it is meant that the pupil shall in every case find by the appropriate means the exact limitation of his observations. This may be illustrated as follows: if he is studying the constituents of soils, he must not be permitted to say, "It is largely sand or gravel," or that the organic matter is small in amount, but he must be required to employ such means as will show him the sand, gravel, etc., in definite and exact amounts. Again, in studying the color of butterflies, for instance, in its relation to the environment, the pupil must not be allowed to put his results in the usual indefinite way, "I think in most cases the butterfly seeks protective surroundings," but he must be required to say in how many cases he has seen the butterfly actually do so. In studying the growth of plants he must not be allowed to say, "The tree averages about so much," but he must by actually measuring find out, as closely as may be, what the average growth is. In short, the first question which both teacher and pupil must have uppermost in mind, when contemplating any experiment or observation, is, "What is the appropriate means of measuring which will enable me to precisely determine the limit of my observations in this case."

After the data have been collected by means

appropriate to the nature of the subject and the capacity of the child, the work of comparison begins. This is the fruitful, the really educative part of the work. The collection of data gives skill and requires nicety in manipulation, it is disciplinary, but it is not educative in a broad sense. It does not give the broad concepts that come only from comparing results so collected.

In making comparisons there may be recognized four modes, each distinct in character from the other; nevertheless, they are modes of comparison because they each so present data to the mind that the relations between them may be seen. These four modes in their cumulative complexity also bear a natural relation to the development of the child's mind. The first mode of comparison which a child uses is where all the qualities are considered as wholes. Under this mode, the genesis of the four fundamental operations as means of comparison may be illustrated by the following examples: the child has, for instance, two sticks of different lengths; his very first comparison respecting length is expressed by saying either, "One is longer than the other," or "One is shorter than the other." In the first case he is looking at the long stick and thinks, "It is like the short stick with more to it." This is his initial thought in addition. In the second case he is looking at the short stick and thinks, "It is like the long stick with part of it taken away." This is his initial thought in subtraction. Very soon he is able to say exactly *how much* must be added to the one or taken from the other, and at that stage

the definite processes of addition and subtraction begin.

A little later, as he looks at the short stick, he thinks, for instance, "If I could put two or more of my short sticks together, they would then be like my long stick." This is his initial step in multiplication. Or, looking at the long stick, he may think, "If I could cut it into two or more equal pieces, I should then have two or more pieces like the short stick." This is the beginning of division. In these first steps in comparison the child naturally employs whole numbers in the four fundamental operations given in the books as addition, subtraction, multiplication, and division.

The second mode of comparison is by considering one of the quantities directly as a part of the other. The child now says, "The short stick is one-half the length of the other." This is his first step in partition, and at this stage he is ready to begin the study and use of fractions.

In the third mode of comparison, the child may use either quantity as the standard, but he must be able to conceive of it as being represented by unity. Thus in two trees, if one is twenty feet high and another eighty feet, he must not only be able to see that one is sixty feet higher than the other; that it is four times the height of the other; that the shorter is one-fourth the height of the taller, but also that, if the shorter is represented by one, the longer is represented by four; also, if the longer is one, the shorter is one-fourth. This mode, including all of what is given under ratio and proportion, is of

more difficult application than either of the others and should be introduced later in the work of the pupil, but not so late as might be inferred from the place usually assigned to it in books on arithmetic.

In the fourth mode of comparison the pupil must be able to grasp what has been described in the first, second, and third modes, and must, besides, be able to conceive of one of the quantities being represented by one hundred. Under this mode are included all the operations that belong to percentage in the text-books. If, in the examination of soils, he finds ten grams of gravel in fifty grams of soil, the pupil will say that if the soil is represented by one hundred the gravel will be represented by twenty; that is, twenty per cent. of the soil is gravel.

From this discussion, it will be seen that, as early as the pupil is able to make a definite observation, he has at his command, and does in fact naturally employ, a mode of comparison corresponding to his stage of development; also, that each mode of comparison rests upon a corresponding mathematical operation; and further, these operations tend to clear up and define his ideas of the subject he studies. It will also be observed that with the exception of such exercises as are intended to be used for the purpose of fixing the units of measurement the whole of arithmetic is included under these four great modes of comparison. It follows, that any subject or subjects which can furnish a sufficient amount of legitimate material to provide problems enough in these four modes of comparison, will meet even the present demand for arithmetic in

the schools. The amount of material actually demanding such number work, which may be gathered from the beginning in the domain of natural science, is, practically, only determined by the intelligence of the teacher in directing his pupil, and by the limitations imposed by adverse conditions under which most teachers labor. The test which the teacher must apply to such problems is, first, are they good science? That is, will their solution tend to clear up the concept sought? And second, are they good arithmetic? That is, do they involve any absurdity in calculation? If they fulfill legitimate demand of science, and do not outrage the canons of number, they should be admitted as properly educative factors.

Before leaving the subject, a word should be said about the method of teaching upon this new basis. New wine must not be put into old bottles. The same principle, precisely, holds in this case that is already recognized to some extent and obeyed in teaching other subjects. Formerly, spelling, reading, etc., were taught as ends; now *thought* is the end and they are incidental. The fatal mistake that has been made is in teaching the *thought* and making the spelling, etc., accidental. There is a mighty difference between the *incidental* teaching of form subjects and the *accidental* teaching of them. So now, in this number work, the teacher must clearly work for the intrinsic thought and make the teaching of the arithmetical operations incidental, but by no means accidental. These processes must be just as thoroughly taught as ever before; they will be more thoroughly taught in far less time, too, when

teachers really grasp the subject matter in hand. The reason for this faith has its source in the pedagogical fact that in the new order of things the intrinsic thought of the subject will demand the operations; and the pupil, if properly directed by the teacher, will feel this actual demand, and his mind will work for them at its highest possible tension. We lose enormously by working at a subject with our pupils when their minds have a low tension—a low potential, to borrow a term from physics. We all know from experience and observation how quickly and strongly even seemingly dull minds grasp facts, principles, and operations when they are rendered really alert by an actual desire to get the thought. This, then, is the first duty of the teacher in the present case: stimulate the mind to its greatest activity with the subject matter, and then definitely direct this activity by means of the various arithmetical operations. Questions prepared in connection with the science work from any other motive will be utterly useless and they will render the pupils as listless as the most arid arithmetic ever used.

METRIC TABLES.

MEASURES OF EXTENSION.

The **Meter** is the *unit of length*, and is equal to 39.37 in., nearly.

TABLE.

Metric Denominations.			U. S. Value.
	1 Millimeter	=	.03937079 in.
10 Millimeters, *mm.*	=1 Centimeter	=	.3937079 in.
10 Centimeters, *cm.*	=1 Decimeter	=	3.937079 in.
10 Decimeters, *dm.*	=1 **Meter**	=	39.37079 in.
10 METERS, *M.*	=1 Dekameter	=	32.808992 ft.
10 Dekameters, *Dm.*	=1 Hectometer	=	19 927817 rd.
10 Hectometers, *Hm.*	=1 Kilometer	=	.6213824 mi.
10 Kilometers, *Km.*	=1 Myriameter(*Mm*)	=	6.213824 mi.

The **Are** is the *unit of land measure*, and is a square whose side is ten meters, equal to a *square dekameter*, or 119.6 square yards.

TABLE.

1 Centiare, *ca.*	=(1 Sq. Meter)	= 1.196034 sq. yd.
100 Centiares, "	= 1 **Are**	= 119.6034 sq. yd.
100 ARES *A.*	= 1 Hectare (*Ha.*)	= 2.47114 acres.

MEASURES OF CAPACITY.

The **Liter** is the *unit of capacity*, both of Liquid and of Dry Measures, and is a vessel whose volume is equal to a cube whose edge is *one-tenth* of a *meter*. equal to 1.05673 qt. Liquid Measure, and .9081 qt. Dry Measure.

TABLE.

10 Milliliters,	*ml.*	. . .	= 1 Centiliter.
10 Centiliters,	*cl.*	. . .	= 1 Deciliter.
10 Deciliters,	*dl.*	. . .	= 1 **Liter.**
10 LITERS,	*L.*	. .	= 1 Dekaliter.
10 Dekaliters,	*Dl.*	. . .	= 1 Hectoliter.
10 Hectoliters,	*Hl.*	. . .	= 1 Kiloliter, or Stere.
10 Kiloliters,	*Kl.*	. . .	= 1 Myrialiter (*Ml.*)

The *Hectoliter* is the *unit* in measuring liquids, grain, fruit, and roots in large quantities.

MEASURES OF WEIGHT.

The **Gram** is the *unit of weight*, and equal to the weight of a cube of distilled water, the edge of which is *one hundredth* of a *meter*, equal to 15.432 Troy grains.

TABLE.

			U. S. Value.
10 Milligrams,	*mg.*	=1 Centigram =	.15432+gr. Troy
10 Centigrams,	*cg.*	=1 Decigram =	1.54324+ "
10 Decigrams,	*dg.*	=1 **Gram** =	15.43248+ "
10 GRAMS,	*G.*	=1 Dekagram =	.35273+oz. Avoir
10 Dekagrams,	*Dg.*	=1 Hectogram=	3.52739+ " "
10 Hectograms,	*Hg.*	=1 {Kilogram or **Kilo.**} =	2.20462+lb. "
10 Kilograms,	*Kg.*	=1 Myriagram=	22.04621+ " "
10 Myriagrams, or 100 Kilograms,	*Mg.*	} =1 Quintal =	220 46212+ " "
10 Quintals, or 1000 KILOS		} =1 {Tonneau or **Ton**} =	2204.62125 " "

ZOÖLOGY.

COLORS OF INSECTS.

The brilliant coloring of many insects that may be easily found renders this department of nature study of interest to the younger as well as to the more advanced pupils. That the colors displayed perform some important function in the life of the insect can not be a matter of doubt; but what their full import is can hardly be called, as yet, a settled question. In many instances, the colors serve as a protection through their similarity to or harmony with the surroundings, while in other cases this is not very evident —the colors being rather an advertisement of the insect's whereabouts. This is probably for the benefit of its mate. The question of adaptation to environment is one which is almost immediately raised, and here, as with plant life, it is one of great interest.

The number selected for study must vary with the different conditions under which the work is done, but it should always be as large as possible so that the errors of observation may be minimized in the final result. The outcome of the work, if well done, will be to lead the pupils a little nearer the laws of life which govern all living things, and to render the pupil a little cautious about accepting assertions until he has applied the test of his experience.

The small yellow butterfly (*Colias*) and the large

brown milk-weed butterfly (*Danais*) are abundant, and make excellent objects for study.

I. WHOLE NUMBERS.

1. In fifty observations, how many times have you seen the *same kind* of butterfly alight upon flowers whose colors are protective, *i.e.*, which tend to make the insect inconspicuous?

2. In how many instances were the flowers of the same color as the insect?

3. In how many instances were the flowers of such colors as to merely harmonize with the insect's colors?

4. How many times did they alight upon plants or in situations where their colors rendered them conspicuous?

5. Compare the results obtained in (1) and (4); how many more in one case than the other?

6. In twenty-five observations, how many times have you seen the *same* butterfly alight in protective situations?

7. In how many cases was the insect rendered more conspicuous by its surroundings?

8. Compare the results obtained in (6) and (7); which is in excess, and how much?

9. Observe each one of ten *different kinds* of butterflies alight twenty-five times; which exceeded, and how much, those selecting protective or those taking non-protective situations in the majority of cases?

10. Collect twenty-five different kinds of insects; how many are there whose colors are especially protective?

11. How many are there whose coloring is of no special importance?

II. FRACTIONS.

1. In fifty observations, what part of the entire number of butterflies observed alighted in protective situations?

2. What part of the entire number alighted in non-protective situations?

3. The number selecting protective situations equals what part of the number selecting places non-protective?

4. What part of the entire number always selected protective situations?

5. What part of the entire number never selected protective situations?

6. Of twenty-five different butterflies of the *same kind*, observe each one alight ten times; what is the average number of times where the situation was protective?

7. What is the average of the number of times where the situation was non-protective?

8. Of ten butterflies of *different kinds*, what part in the majority of cases selected protective situations?

9. Of twenty-five different kinds of insects, what part of the whole number is protected by coloring?

10. What part is not so protected?

III. RATIO.

1. In fifty observations upon the *same kind* of butterfly, what is the ratio of those seeking flowers that have protective coloring to those indifferent

to such conditions? What is the ratio of the latter to the former?

2. In twenty-five observations upon the same butterfly, what is the ratio of the number of times that it selected protective to the number of times that it selected non-protective situations?

3. In ten different kinds of butterflies, what is the ratio of those that selected situations with protective coloring, in the majority of cases, to those that selected non-protective places?

4. In twenty-five different kinds of insects, what is the ratio of those that make special use of protective coloring of their surroundings to those that do not?

IV. PERCENTAGE.

1. In fifty observations, what per cent of the *entire number* of butterflies alighted upon flowers whose colors rendered them less conspicuous?

2. What per cent of the entire number were rendered more conspicuous?

3. In twenty-five observations, the number of times the *same* butterfly seemed to select protective situations is what per cent of the whole?

4. What per cent of the whole is the number of cases where insect was rendered more conspicuous by its surroundings?

5. In ten observations upon each of ten different butterflies, what per cent selected, in a majority of cases, situations which rendered them less conspicuous when they alighted?

6. What per cent of the whole were rendered more conspicuous by their surroundings?

7. Collect twenty-five different kinds of insects; what per cent of the number have protective coloring?

8. What per cent of the number do not have protective coloring?

9. What per cent of the entire number are rendered more conspicuous by their colors?

10. What per cent of the entire number have some special enemy which they try to avoid?

BOTANY.

MUTUAL RELATIONS OF PLANTS AND ANIMALS—STUDY OF LEAVES.

The following series of problems is designed to accompany an autumn study of leaves. It is intended to show something of the importance of the relations which exist between leaves and the insect life which swarms upon them at this season. An interesting comparison may be made between the present condition of the leaves and that noticed earlier in the season, say, during the month of June. From the large proportion of leaves found to be injured, it would seem, at first, as though the trees must be greatly weakened thereby. In exceptional years this is doubtless true, but, that it is not uniformly true is evident or the result would be the gradual loss of vitality and premature death of the tree. The almost perfect balance which exists between the demand and supply of both insect and plant seems to be largely favored by the fact that the voracious larvæ begin their feeding comparatively late and, before they have destroyed any considerable amount, the function of the leaf in building up the buds and other new materials in the plant has mainly been fulfilled. It will be noticed, too, that the large proportion of leaves injured gives an indication of the even distribution of the work of the insect over the entire tree, thus

reducing, relatively, the loss to each bud. By laying a piece of wire gauze of about one-tenth-inch mesh over the leaf the loss to each may be, by this means, fairly estimated and the results may be definitely stated.

The study should be thoroughly systematic and should conform to the conditions of teacher and pupils. The entire time and attention may be given to a single tree or plant or to a set of the same kind, or the school may be grouped and data gathered from different kinds of plants and interesting comparisons made between them. The number of leaves to be used as a basis of comparison must be determined in each case by the amount of time, the ability of the pupils and by other conditions under which the study is made.

PROBLEMS.

I. Whole Numbers.

1. Of one hundred leaves examined, how many have not been injured or used in any way by animals?

2. How many have been injured?

3. How many have been stung by insects in laying their eggs?

4. How many so stung have apparently lost their usefulness as leaves (*i. e.*, have been swollen into balls or other distorted forms)?

5. How many leaves have been devoured, in part, as food by insects or their larvæ?

6. How many leaves have been used, in some way, by insects in making nests or cocoons?

7. Of one hundred leaves taken from the oak, ash, maple, elm, and box-elder, which has the greatest number injured? Which the least?

8. What is the difference between the number injured on the oak and the number found injured upon the maple?

9. What is the difference between the number injured found on the oak and that found on the ash?

10. What is the difference between the number injured found on the oak and that found on the box-elder?

II. FRACTIONS.

1. Of one hundred leaves examined, what part has not been injured or used in any way by animals?

2. What part has been injured or so used?

3. What part of the entire number has been stung by insects in laying their eggs?

4. What part of the number stung has lost the ordinary leaf form after being stung?

5. What part of the entire number has been devoured partially by insects or their larvæ as food?

6. What part of the entire number examined has been used by insects in nest-building or making cocoons?

7 Of one hundred leaves taken from the oak, ash, maple, elm, and box-elder, which has the greatest part injured, and how much? Which the least, and how much?

8. Of the entire number examined, the part found injured on the oak equals what part of that injured on the maple?

9. Of the entire number examined, the part found injured on the oak equals what part of that found injured on the ash?

10. The number found injured on the oak equals what part of that found injured on the box-elder?

III. RATIO.

1. In one hundred leaves examined, what is the ratio of those that have not been used in any way by insects to those that have been so used?

2. What is the ratio of the number of injured leaves to the entire number observed?

3. What is the ratio of the uninjured leaves to the whole number observed?

4. Of the leaves stung by insects, what is the ratio of those that have remained unchanged in form to the whole number stung?

5. What is the ratio of those stung that have had the leaf-form modified thereby to those that have remained unchanged in form?

6. The number of leaves that have been used in nest-building, or in making cocoons, bears what ratio to the entire number examined?

7. The number of leaves found injured on the oak bears what ratio to the number found injured on the ash?

8. The number of injured leaves on the oak bears what ratio to the number injured on the maple?

9. The number injured on the oak bears what ratio to the number injured on the elm?

10. The number injured on the oak bears what ratio to the number injured on the box-elder?

IV. PERCENTAGE.

1. What per cent of the whole number of leaves examined have been injured by insects?

2. What per cent remain uninjured?

3. What per cent of the entire number observed have been stung by insects in laying their eggs?

4. What per cent of the number stung have lost the ordinary leaf-form as a result of the injury?

5. What per cent of the entire number have been devoured in part by insects, or their larvæ, as food?

6. What per cent of the entire number of leaves examined have been used by insects in making nests or cocoons?

7. In the oak, ash, maple, elm, and box-elder, which has the greatest percentage injured by insects? Which the least?

8. The number of leaves injured upon the oak is what per cent of that found upon the ash?

9. The number of injured leaves found upon the oak is what per cent of that found upon the maple?

10. The number of injured leaves found upon the oak is what per cent of the number found upon the box-elder?

STRUCTURE AND COLORS OF FRUITS.

In the structure and coloring of fruits there is a beautiful adaptation of means to end. The transformation of the green, hard, and usually sour, or bitter, fleshy portion in many fruits, at the maturity of the seeds, into a soft, juicy, and palatable pulp, rendered attractive by beautiful colors, is a change full of meaning to the plant and rich in suggestion to the student. The bearing of this lesson is upon the subject of distribution of seeds and it should be associated with the lessons on that subject. The pupils should collect a great variety of fruits and then proceed to group them. The following classes are suggested:

1. Fleshy Fruits: such as the grape, gooseberry, and cranberry.

2. Stone Fruits: such as the plum, peach, and apricot.

3. Dry Fruits: such as the nuts and the seeds of many weeds.

PROBLEMS.

I. Whole Numbers.

1. How many different fruits have you collected?
2. How many are fleshy fruits?
3. How many in your collection are stone fruits?

4. How many in your collection are dry fruits?

5. Which class is largest and how much?

6. How many different fruits collected are colored conspicuously?

7. How many different fruits collected are not colored conspicuously?

8. How many of those conspicuously colored are fleshy fruits?

9. How many of those conspicuously colored are stone fruits?

10. How many of those conspicuously colored are dry fruits?

11. How many of the fruits in your collection become more conspicuous when ripe?

12. How many are used as food before they ripen?

13. What is the prevalent color among your fruits? How many of each class have this color?

14. How many of the different kinds of highly colored fruits harmonize with the foliage of the plant?

II. FRACTIONS.

1. What part of your entire collection is composed of fleshy fruits?

2. What part of your entire collection is composed of stone fruits?

3. What part of your entire collection is composed of dry fruits?

4. What part of the entire collection is colored conspicuously?

5. The stone fruits are what part of those colored conspicuously?

6. The fleshy fruits are what part of those colored conspicuously?

7. The dry fruits are what part of those colored conspicuously?

8. What part of your entire collection becomes more conspicuous when ripe?

9. What part is used as food before ripe?

10. What is the prevailing color among your fruits? What part of the fleshy fruits has this color? Of the stone fruits? Of the dry fruits?

11. What part of all those highly colored harmonizes with the foliage of the plant?

III. RATIO.

1. What is the ratio of the stone fruits to the entire collection?

2. What is the ratio of the fleshy fruits to the entire collection?

3. What is the ratio of the dry fruits to the entire collection?

4. What is the ratio of the stone fruits to the fleshy fruits?

5. What is the ratio of the dry fruits to the stone fruits?

6. What is the ratio of the dry fruits to the fleshy fruits?

7. What is the ratio of the dry fruits to the stone and fleshy fruits?

8. What is the ratio of those conspicuously colored to the entire collection?

9. What is the ratio of the conspicuously colored stone fruits to the entire number of stone fruits?

10. What is the ratio of the conspicuously colored fleshy fruits to the entire number of fleshy fruits?

11. What is the ratio of the conspicuously colored dry fruits to the entire collection of dry fruits?

12. What is the ratio of the fruits that are used as food by animals before they ripen to the entire number?

13. What is the ratio of the fruits in your collection that become more conspicuous when they ripen to the whole number?

14. What is the prevailing color among your fruits? What is the ratio of the stone fruits having this color to all the stone fruits? Of the fleshy fruits? Of the dry fruits?

IV. PERCENTAGE.

1. The stone fruits are what per cent of the entire collection?

2. The fleshy fruits are what per cent of the entire collection?

3. The dry fruits are what per cent of the entire collection?

4. The number of stone fruits equals what per cent of the number of fleshy fruits?

5. The number of dry fruits equals what per cent of the number of stone fruits? Of stone and fleshy fruits together?

6. The number of conspicuously colored fruits equals what per cent of the whole number?

7. The conspicuously colored stone fruits are what per cent of the entire number of stone fruits?

8. The conspicuously colored fleshy fruits are what per cent of the entire number of fleshy fruits?

9. The conspicuously colored dry fruits are what per cent of the entire number of dry fruits?

10. The number of fruits that are used for food by animals before they ripen is what per cent of the entire number?

11. What per cent of the fruits become more conspicuous as they ripen?

12. What is the prevailing color among the fruits? What per cent of the stone fruits have this color? Of the fleshy fruits? Of the dry fruits?

13. What per cent of the highly colored fruits harmonize with the foliage of the plant?

A STUDY OF THE CONSTITUENTS OF FRUITS.

It is the aim of the following lessons to give the pupils a definite idea of the absolute and relative amounts of fluid matter, dry solid matter, organic matter, and mineral matter, or ash, of which some of the common fruits and vegetables are composed. In order to perform the work required satisfactorily, a small amount of apparatus is necessary: a small set of balances with weights — metric preferred; physicians' scales, with horn scale-pans, and coin weights from twenty grams down to one centigram, will answer the purpose; a Battersea dish with a tripod or retort stand, or other support for it, over the alcohol or Bunsen flame. It is also desirable to have a convenient means for drying the fruits at school. This may be done by providing a small tray, about one inch deep, divided by pasteboard, or thin wooden strips, into forty or fifty compartments, each about one and one-half inches square. Use fine wire gauze for a bottom, and tack the same over the other side for a cover. Mosquito netting may be substituted for the gauze. This tray will give each pupil a compartment for his fruit, and, with a little care, the work of an entire room may be nicely dried. The tray may be hung in the sun and the gauze will enable evaporation to proceed quite rapidly. In

most cases, perhaps, the teacher will have but one set of apparatus to begin with, but, for a beginning, this is sufficient. Take one fruit or vegetable after another and assign different parts of the work to different pupils, and, with a little care and patience, data enough will soon be gathered to enable the pupils to have a fair idea of the component parts of those examined.

With beginners, and with pupils in the lower grades, it will be sufficient to show how much fluid and solid matter the fruit contains, and large pieces should be used; but with pupils more advanced, smaller amounts should be used and all four parts determined.

Proceed as follows:

1. Weigh out a definite amount, say, five grams of the fresh fruit.

2. Dry it until it no longer loses weight—testing from time to time. It must not be subjected to great heat, or charring will take place. This gives the dry solid matter.

3. Powder the dry solid matter* and weigh a definite amount of it and place this in the Battersea dish over the flame. Stir with a glass rod and, when reduced to fine grayish-white ash, weigh again. This gives the mineral matter, or ash.

The data now at hand are as follows:

1. The weight of the fresh material.

2. The weight of the dry solid.

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* The ash may be obtained directly by burning a piece of fresh fruit.

3. The weight of the fluid—obtained by subtracting weight of dry solid from that of the fresh material.

4. The weight of the ash.

5. The weight of the organic matter—obtained by subtracting the weight of the ash from the weight of the dry solid.

PROBLEMS.

I. WHOLE NUMBERS—(*Dry Solid, Fluid, and Fresh Material*).

1. What is the difference between the weight of the fresh fruit and that of the dry solid?

2. What is the difference between the weight of the fluid and that of the dry solid?

3. What is the difference between the weight of the fresh material and that of the fluid?

4. The weight of the fresh material is how many times the weight of the dry solid?

5. The weight of the fresh material is how many times the weight of the fluid?

6. What is the difference between the weight of the dry solid obtained from ten grams of apple and that obtained from the same amount of potato?

7. What is the difference between the weight of the fluid in ten grams of apple and the weight of the fluid in ten grams of potato?

8. What is the difference between the dry solid contained in ten grams of turnip and the dry solid in the same amount of sweet potato? What difference between the amounts of fluid in the two?

9. What is the difference between the weight of

dry solid in ten grams of parsnip and that in the same amount of a beet?

10. What is the difference in weight between the dry solid in ten grams of cucumber and the dry solid in ten grams of squash?

II. FRACTIONS—(*Dry Solid, Fluid, Fresh Material, Organic Matter, and Ash*).

1. The weight of the dry solid is what part of the weight of the fresh material?

2. The weight of the fluid is what part of the weight of the fresh material?

3. The weight of the ash is what part of the weight of the fresh material?

4. The weight of the organic matter is what part of the weight of the fresh material?

5. The weight of the dry solid is what part of the weight of the fluid?

6. The weight of the dry solid is what part of the weight of the ash?

7. The weight of the dry solid is what part of the weight of the organic matter?

8. The weight of the fluid is what part of the weight of the dry solid?

9. The weight of the fluid is what part of the weight of the ash?

10. The weight of the fluid is what part of the weight of the organic matter?

11. The weight of the ash is what part of the weight of the fluid?

12. The weight of the ash is what part of the weight of the dry solid?

13. The weight of the ash is what part of the weight of the organic matter?

14. The weight of the organic matter is what part of the weight of the dry solid?

15. The weight of the organic matter is what part of the weight of the fluid?

16. The weight of the organic matter is what part of the weight of the ash?

17. In one bushel of potatoes, how many pounds of fluid? Of ash? Of organic matter? Of dry solid?

18. In one barrel of apples, how many pounds of fluid? Of ash? Of organic matter? Of dry solid?

19. In one bushel of turnips, how many pounds of fluid? Of ash? Of organic matter? Of dry solid?

20. In one bushel of beets, how many pounds of fluid? Of ash? Of organic matter? Of dry solid?

III. Ratio.

1. What is the ratio, by weight, of the dry solid to the fresh material?

2. What is the ratio, by weight, of the fluid to the fresh material?

3. What is the ratio, by weight, of the ash to the fresh material?

4. What is the ratio, by weight, of the organic matter to the fresh material?

5. What is the ratio, by weight, of the dry solid to the fluid?

6. What is the ratio, by weight, of the dry solid to the ash?

7. What is the ratio, by weight, of the dry solid to the organic matter?

8. What is the ratio, by weight, of the fluid to the ash?

9. What is the ratio, by weight, of the fluid to the organic matter?

10. What is the ratio, by weight, of the ash to the organic matter?

11. What is the ratio, by weight, of the fluid in an apple to that in a turnip?

12. What is the ratio, by weight, of the ash in an apple to the ash in a turnip?

13. What is the ratio, by weight, of the organic matter in an apple to that in a potato?

14. What is the ratio, by weight, of the dry solid in a potato to that in a turnip?

15. What is the ratio, by weight, of the fluid in a parsnip to that in a beet?

16. In a bushel of potatoes how much fluid, dry solid, ash, and organic matter?

17. In one barrel of apples how much fluid, dry solid, ash, and organic matter?

18. In a bushel of turnips how much fluid, dry solid, ash, and organic matter?

19. In a bushel of parsnips how much fluid, dry solid, ash, and organic matter?

20. In a bushel of beets how much fluid, dry solid, ash, and organic matter?

IV. PERCENTAGE.

1. The weight of the dry solid is what per cent of the weight of the fresh material?

2. The weight of the fluid is what per cent of the weight of the fresh material?

3. The weight of the ash is what per cent of the weight of the fresh material?

4. The weight of the organic matter is what per cent of the weight of the fresh material?

5. The weight of the dry solid is what per cent of the weight of the fluid? The fluid, of the dry solid?

6. The weight of the dry solid is what per cent of the weight of the ash? The ash, of the dry solid?

7. The weight of the dry solid is what per cent of the weight of the organic matter? The organic matter, of the dry solid?

8. The weight of the fluid is what per cent of the weight of the ash? The ash, of the fluid?

9. The weight of the fluid is what per cent of the weight of the organic matter? The organic matter, of the fluid?

10. The weight of the ash is what per cent of the weight of the organic matter? The organic matter, of the ash?

11. The amount of dry solid in a turnip is what per cent, by weight, of that in an apple?

12. The amount of ash in a turnip is what per cent, by weight, of that in an apple?

13. The amount of organic matter in a turnip is what per cent, by weight, of that in a potato?

14. The amount of ash in a turnip is what per cent, by weight, of that in a potato?

15. The amount of fluid in a parsnip is what per cent, by weight, of the amount in a beet?

16. In a bushel of potatoes, how much dry solid, fluid, ash, and organic matter?

17. In a barrel of apples, how much dry solid, fluid, ash, and organic matter?

18. In a bushel of turnips, how much dry solid, fluid, ash, and organic matter?

19 In a bushel of parsnips, how much dry solid, fluid, ash, and organic matter?

20. In a bushel of beets, how much dry solid, fluid, ash, and organic matter?

PHYSICS.

EVAPORATION OF LIQUIDS.

In order to use the following problems, it is necessary to have vessels, similar to those here described, whose dimensions are known. They can be made by any tinsmith at a trifling cost. No. I is cubical, six centimeters on each edge. No. II is rectangular, twelve centimeters long, six wide, and three deep. No. III is rectangular, twelve centimeters long, three wide, and six deep. No. IV is rectangular, six centimeters long, three wide, and twelve deep. No. V is right-triangular, the sides adjacent to the right angle being each six centimeters, the depth being twelve. It will be seen that these vessels are of equal capacity, but that the surface area exposed varies. In setting these vessels for the experiment, it is best to place them in a small box of dry saw-dust, so that the variation due to the exposure of unequal side areas to the air may be, practically, eliminated.

To measure the amount of evaporation, construct a small frame to stand over each vessel. Through a cross-piece in this frame directly over the vessel pass a steel knitting-needle, the lower end of which must be filed to a very sharp point. To the upper side of the cross-piece, just behind the needle, fasten a small strip of wood about two centimeters wide and four high; on the face of this, next to the needle, tack a

piece of thin copper, brass, or tin and rule upon it horizontal lines, one millimeter apart. Heat the upper end of the needle and bend the tip of it at right angles so that it will pass over the face of the scale.

To take the observation, fill the vessels nearly to the top with the liquid to be studied, and move the needle down until the point comes in contact with the surface. The surface may be slightly varied by means of a dropping tube so that the upper end of the needle will rest exactly on one of the lines of the scale when the point is in contact with the liquid. Place the vessels, under whatever conditions desired, for a definite time; then, push the needle down until the point again comes in contact with the surface, and read on the scale the number of millimeters passed over by the upper end. This will give the depth evaporated, and the volume may be calculated. In determining the point of contact of the needle and liquid it is best to place the eye so that the *reflection* of the needle may be seen rising to meet the descending point; the surface is at the exact point of the meeting of the two. All the vessels may be placed under the same conditions, or one may be placed under different conditions at different times; or all the vessels may be so used. These observations render it necessary for the pupils to calculate areas and volumes that the subject of evaporation may be definitely understood. It is, therefore, directly a study of evaporation, which is a study of heat and atmospheric conditions and, incidentally, a practical study of the subject of mensuration.

PROBLEMS.

I. WHOLE NUMBERS.—*A. Conditions and time the same for all the vessels.*

1. What is the volume evaporated from No. I? What is the average per hour?

2. What is the volume evaporated from No. II? Average per hour?

3. What is the volume evaporated from No. III? Hourly average?

4. What is the volume evaporated from No. IV? Hourly average?

5. What is the volume evaporated from No. V? Hourly average? Measure off in a graduate the above amounts that the pupils may become familiar with the different volumes.

6. Which evaporated the more, and how much, No. I or No. II?

7. Which has the larger surface, and how much, No. I or No. II?

8. Which evaporated the more, and how much, No. I or No. IV?

9. Which has the greater area exposed, and how much, No. I or No. IV?

10. Which evaporated the larger volume, and how much, No. I or No. V?

11. Which has the larger area exposed, and how much, No. I or No. V?

12. Which evaporated the larger volume, and how much, No. II or No. III?

13. Which has the larger area exposed, and how much, No. II or No. III?

14. Which evaporated the more, and how much, No. II or No. IV?

15. Which has the larger area exposed, and how much, No. II or No. IV?

16. Which evaporated the more, and how much, No. IV or No. V?

17. Which has the larger surface exposed, and how much, No. IV or No. V?

B. Different conditions.

18. Which is greater, and how much, the hourly average of the vessels when inside a room or on the outside of the window sill?

19. Which is greater, and how much, the hourly average, when the vessels are in a window, with the window open, or with it closed?

20. Which is greater, the hourly average on a rainy day or a clear day?

21. Which is greater, and how much, the hourly average with the vessels in a closed cupboard or in an open room?

22. Which is greater, and how much, the evaporation with the vessels in sunshine or in the shade?

II. FRACTIONS.—*A. Conditions and time the same for all the vessels.*

1. The volume evaporated from No. I equals what part of that evaporated from No. II?

2. The area exposed in No. I equals what part of that exposed in No. II?

3. The amount evaporated from No. I equals what part of that evaporated from No. III?

4. The area exposed in No. I equals what part of that exposed in No. III?

5. The amount evaporated from No. I equals what part of that evaporated from No. IV?

6. The area exposed in No. I equals what part of that exposed in No. IV?

7. The amount evaporated from No. I equals what part of that evaporated from No. V?

8. The area exposed in No. I equals what part of that exposed in No. V?

9. The amount evaporated from No. II equals what part of that evaporated from No. III?

10. The area exposed in No. II equals what part of that exposed in No. III?

11. The amount evaporated from No. II equals what part of that evaporated from No. IV?

12. The area exposed in No. II equals what part of that exposed in No. IV?

13. The amount evaporated from No. II equals what part of that evaporated from No. V?

14. The area exposed in No. II equals what part of that exposed in No. V?

15. The amount evaporated from No. IV equals what part of that evaporated by No. V?

16. The area exposed in No. IV equals what part of that exposed in No. V?

B. Different conditions.

17. The hourly average evaporated with the vessels in a closed cupboard equals what part of the average when they are in a room?

18. The hourly average with the vessels near a closed window equals what part of the average when the window is open?

19. The hourly average on a dry day equals what part of that on a rainy day?

20. The hourly average with the vessels in the sunshine equals what part of that when they are in the shade?

21. The hourly average with the vessels outdoors equals what part of that when they are indoors?

III. RATIO.—*A. Conditions and time the same for all the vessels.*

1. What is the ratio of the volume evaporated from No. I to that evaporated from No. II?

2. What is the ratio of the area exposed in No. I to that exposed in No. II?

3. What is the ratio of the volume evaporated from No. I to that evaporated from No. III?

4. What is the ratio of the area exposed in No. I to that exposed in No. III?

5. What is the ratio of the volume evaporated from No. I to that evaporated from No. IV?

6. What is the ratio of the area exposed in No. I to that exposed in No. IV?

7. What is the ratio of the amount evaporated from No. I to that evaporated from No. V?

8. What is the ratio of the area exposed in No. I to that exposed in No. V?

9. What is the ratio of the amount evaporated from No. II to that evaporated from No. III?

10. What is the ratio of the area exposed in No. II to that exposed in No. III?

11. What is the ratio of the amount evaporated from No. II to that evaporated from No. IV?

12. What is the ratio of the area exposed in No. II to that exposed in No. IV?

13. What is the ratio of the amount evaporated from No. II to that evaporated from No. V?

14. What is the ratio of the area exposed in No. II to that exposed in No. V?

15. What is the ratio of the amount evaporated from No. IV to that evaporated from No. V?

16. What is the ratio of the area exposed in No. IV to that exposed in No. V?

B. Different conditions.

17. What is the ratio of the hourly average of evaporation when the vessels are in a closed cupboard to that when they are in an open room?

18. What is the ratio of the hourly average of evaporation when the vessels are near a closed window to that when the window is open?

19. What is the ratio of the hourly average of evaporation on a rainy day to that on a clear day?

20. What is the ratio of the hourly average of evaporation when the vessels are in the sunshine to that when they are in the shade?

21. What is the ratio of the hourly average of evaporation when the vessels are outdoors to that when the vessels are indoors?

IV. PERCENTAGE.—*A. Conditions and time the same for all the vessels.*

1. The volume evaporated from No. I equals what per cent of that evaporated from No. II?

2. The area exposed in No. I equals what per cent of that exposed in No. II?

3. The volume evaporated from No. I equals what per cent of that evaporated from No. III?

4. The area exposed in No. I equals what per cent of that exposed in No. III?

5. The volume evaporated from No. I equals what per cent of that evaporated from No. IV?

6. The area exposed in No. I equals what per cent of that exposed in No. IV?

7. The volume evaporated from No. I equals what per cent of that evaporated from No. V?

8. The area exposed in No. I equals what per cent of that exposed in No. V?

9. The volume evaporated from No. II equals what per cent of that evaporated from No. III?

10. The area exposed in No. II equals what per cent of that exposed in No. III?

11. The volume evaporated from No. II equals what per cent of that evaporated from No. IV?

12. The area exposed in No. II equals what per cent of that exposed in No. IV?

13. The volume evaporated from No. II equals what per cent of that evaporated from No. V?

14. The area exposed in No. II equals what per cent of that exposed in No. V?

15. The amount evaporated from No. IV equals what per cent of that evaporated from No. V?

16. The area exposed in No. IV equals what per cent of that exposed in No. V?

B. Different conditions.

17. The hourly average evaporated with the vessels in a closed cupboard equals what per cent of that evaporated when they are in a closed room?

18. The hourly average evaporated when the vessels are near a closed window equals what per cent of that when the window is open?

19. The hourly average evaporated on a dry day equals what per cent of that evaporated on a wet one?

20. The hourly average evaporated when the vessels are in the sunshine equals what per cent of that when they are in the shade?

21. The hourly average evaporated when the vessels are outdoors equals what per cent of that when they are indoors?

METEOROLOGICAL RECORD FOR.....189

Time of Observation..... *By*.....*Grade*.....

DAY	DATE	Frost or Dew	Direction of Wind	Cloudiness Fogs	Rainfall	Temperature	Barometer	Sun Rises	Sun Sets	Moon's Phases	Moon Rises	Moon Sets	Morning Star	Evening Star
WEEKLY SUMMARY														

METEOROLOGY.

In order to gather the data required for the following problems, it is necessary that the pupils keep a daily weather record.* A blank form, sufficient for a week's record, devised for the public schools, is here copied from NATURE STUDY FOR THE COMMON SCHOOLS, in which book its use is more fully described. As soon as the pupils can do the work, each should be provided with a sheet large enough to contain a month's record.

The teacher should apply to the nearest Weather Bureau Office for the daily weather maps, and they, together with a valuable monthly summary, will be sent free of charge. With these the pupils' observations may be supplemented and corrected.

With small children, the record may be kept on the blackboard by the teacher, and only such points noticed as the children are able to give themselves, such as direction of wind, clouds, etc.

I. WHOLE NUMBERS.

A. Temperature.

1. What is the difference between the lowest and the highest temperature for September?

*A Science Record, devised by the author, contains a sufficient number of blank forms for a year's work. It is also provided with blank pages for writing, and drawings, and a mineralogical record.

2. What is the average temperature for the month?

3. What is the average temperature for the first week? The second? The third? The fourth?

4. What is the greatest difference in the average temperature between any two weeks of the month?

B. Barometer.

5. What is the average hight of the barometer for September?

6. What is the difference between the lowest and the highest reading for the month?

7. What is the average hight for the first week? The second? The third? The fourth?

8. What is the greatest difference between the average hights for any two weeks?

C. Rainy, Cloudy, and Clear Days.

9. How many rainy days during September? Cloudy days? Cloudy days without rain? Clear days?

10. What is the difference between the number of rainy days and the number of cloudy days?

11. What is the difference between the number of rainy days and the number of clear days?

12. What is the difference between the number of cloudy days and the number of clear days?

13. At the September rate, how many rainy days would there be in a year? How many cloudy days? How many clear days?

D. Rainfall.

14. What is the total rainfall for the month?

15. What is the average rainfall for each day of the month?

16. What is the average rainfall for each cloudy day in the month?

17. What is the average rainfall for each rainy day in the month?

18. At the September rate, what would be the total rainfall for a year?

E. Dew, Frost, and Fogs.

19. How many mornings during the month were with dew?

20. Which is the greater, and how much, the number of mornings with dew or the number with frost?

21. On how many mornings were fogs noted?

22. What is the difference between the number of clear mornings and the number of foggy mornings? With dew, and without dew?

II. FRACTIONS.

A. Temperature.

1. The lowest reading of the thermometer for the month of September is what part of the highest?

2. The average reading of the thermometer for the first week is what part of that for the month? For the second week? For the third week? For the fourth week?

3. The average reading of the thermometer for the first week is what part of that for the second? The third? The fourth?

B. Barometer.

4. The average hight of the barometer for

September is what part of the highest reading? The lowest?

5. The average hight for the first week is what part of that for the second? The third? The fourth?

6. The average hight during the rainy days is what part of that for the entire month?

7. The average hight for the rainy days is what part of that for the cloudy days?

8. The average hight for the rainy days is what part of that for the cloudy days that were without rain?

9. The average hight for the rainy days is what part of that for the clear days?

C. Rainy, Cloudy, and Clear Days.

10. The number of rainy days is what part of the entire month?

11. The number of rainy days equals what part of the number of cloudy days?

12. The number of rainy days equals what part of the number of clear days?

13. The number of cloudy days is what part of the entire month?

14. The number of cloudy days without rain is what part of the entire month?

15. The number of clear days is what part of the entire month?

16. What wind accompanied the greater part of the number of cloudy days?

17. What wind accompanied the greater part of the number of clear days?

D. Rainfall.

18. What part of the total rainfall fell the first week? The second? The third? The fourth?

19. The daily average rainfall for the rainy days equals what part of that for the entire month?

20. The daily average rainfall for the rainy days equals what part of that for the total number of cloudy days?

21. The daily average rainfall for the days on which the prevailing wind blew equals what part of that for the other days of the month?

E. Dew, Frost, Fogs.

22. The dewy mornings are what part of the entire month?

23. The mornings with frost are what part of the entire month?

24. The mornings with fogs are what part of the entire month?

III. RATIO.

A. Temperature.

1. What is the ratio of the lowest reading of the thermometer to the highest in September?

2. What is the ratio of the average reading of the thermometer of the first week to that of the second? Of the second to the third? Of the third to the fourth?

3. What is the ratio of the average reading of the thermometer of the first week to the monthly average? Of the second week? Of the third week? Of the fourth week?

B. Barometer.

4. What is the ratio of the lowest to the highest reading for the month?

5. What is the ratio of the average reading for the rainy days to that for the clear days?

6. What is the ratio of the average reading for the cloudy days to that for the clear days?

7. What is the ratio of the average reading on the rainy days to that of the cloudy days without rain?

8. What is the ratio of the average reading on the cloudy days without rain to that for the clear days?

C. Rainy, Cloudy, and Clear Days.

9. What is the ratio of the number of rainy days to the number of clear days?

10. What is the ratio of the number of rainy days to the number of cloudy days?

11. What is the ratio of the number of rainy days to the number of cloudy days without rain?

12. What is the ratio of the number of cloudy days to the number of clear days?

13. What is the ratio of the number of cloudy days without rain to the number of clear days?

D. Rainfall.

14. What is the ratio of the rainfall of the first week to the total for the month? Of the second week? Of the third week? Of the fourth?

15. The daily average rainfall for the rainy days bears what ratio to the daily average for the month?

16. The daily average for the rainy days bears what ratio to the daily average for the cloudy days?

E. Dew, Frost, Fog.

17. What is the ratio of the dewy mornings to those with frost?

18. What is the ratio of the number of foggy mornings to the number without fogs?

IV. PERCENTAGE.

A. Temperature.

1. The lowest reading of the thermometer for the month is what per cent of the highest?

2. The average reading of the thermometer for the first week is what per cent of that for the month? Of the second week? Of the third week? Of the fourth week?

3. The average reading of the thermometer for the rainy days is what per cent of that for the clear days?

4. The average reading of the thermometer for the cloudy days is what per cent of that for the clear days?

5. The average reading of the thermometer for the rainy days is what per cent of that for the cloudy days without rain?

B. Barometer.

6. The lowest barometric reading for the month is what per cent of the highest?

7. The average hight of the barometer for the first week is what per cent of that for the month? Of the second? Of the third? Of the fourth?

8. The average hight of the barometer during the rainy days is what per cent of that during the clear days?

9. The average hight of the barometer during the cloudy days is what per cent of that during the clear days?

10. The average hight of the barometer during the rainy days is what per cent of that during the cloudy days without rain?

11. The average hight of the barometer for the days on which the prevailing wind blew is what per cent of that for the other days of the month?

C. Rainy, Cloudy, and Clear Days.

12. The number of rainy days is what per cent of the entire month?

13. The number of cloudy days is what per cent of the entire month?

14. The number of clear days is what per cent of the entire month?

15. The number of rainy days is what per cent of the number of cloudy days?

16. The number of rainy days equals what per cent of the number of clear days?

17. The number of cloudy days equals what per cent of the number of clear days?

18. The rainy days with the wind in the prevailing direction for the month equals what per cent of the number with the wind in other directions?

D. Rainfall.

19. The average daily rainfall for the rainy days is what per cent of that for the entire month?

20. The average rainfall for the rainy days is what per cent of that for the cloudy days?

21. The rainfall of the first week is what per cent of that for the entire month? Of the second week? Of the third week? Of the fourth week?

22. The rainfall on the days when the wind blew in the prevailing direction is what per cent of that which fell on the other days of the month?

E. Dew, Frost, Fogs.

23. The dewy mornings are what per cent of the entire month?

24. The frosty mornings are what per cent of the entire month?

25. The days with fogs are what per cent of the entire month?

ASTRONOMY.

THE MUTUAL RELATIONS OF THE EARTH AND SUN.

It is a fact, easily within the comprehension of very young pupils, that the condition of things, as we now find them on the earth, is absolutely dependent upon the particular relation which now exists between the earth and sun. It follows, therefore, that a proper study and knowledge of this relation is one of fundamental importance, if the phenomena of climate and life distribution are to be at all understood. In this study, it is a singular fact that, while it is possible for pupils of public-school age, wherever they may be situated, to make a large number of observations, it is true that all, or nearly all, of these observations will lead them directly away from the truth regarding the earth and the sun. The earth appears to be flat, but it is really round, like a ball; it seems to be stationary, but it is in inconceivably rapid motion—in fact, it has several motions. The sun appears to sweep through a great arc in the heavens daily, and to rise toward the zenith, and then sink toward the horizon, in the course of a year, moving on a spiral line; relatively, though, it is stationary. The sun seems to be much smaller than the earth, but it

really is vastly larger. Unaided, it is impossible for the pupil to reach the truth with any means that he is able to employ, and it is necessary, therefore, that the teacher place before him, in proper order, a series of statements of certain leading facts that have been determined by prolonged observation and accurate measurements. By this means, the observations of the pupils will gradually assume a proper significance to them. In their study of mathematical geography, it often happens that pupils do not get a proper concept of the size, distances, and rates of motion, actual or relative, of the heavenly bodies. While it is not possible to approach an adequate concept of these, as they actually are, by proper means, an intelligent notion may be given of the relations that exist.

A few suggestions are given to indicate to the teacher how the observations of the pupils may be utilized in this study.

I. CONCERNING THE EARTH'S SHAPE.

1. The earth appears to be flat; if it were really flat, what would be the fact concerning sunrise to the inhabitants on different parts of the earth's surface?

2. How would sunset appear under the same condition?

3. The sun appears to be smaller than the earth; if it were really so and if the earth were flat, what would be the facts concerning the forenoon, noon, and afternoon on different parts of the earth's surface?

(*a*) *Statement.* The sun is approximately eight hundred sixty thousand miles in diameter; the diameter of the earth is eight thousand miles.

4. The diameter of the earth bears what ratio to that of the sun?

5. If the diameter of the sun *appears* to you to be two feet (teacher will take the average apparent diameter as given by the pupils) what would the diameter of the earth *appear* to be if you were on the sun?

6. Suppose you represent the diameter of the earth by a line one inch long, by what length of line must you represent the diameter of the sun?

(*b*) *Statement.* The distance from the earth to the sun is ninety-three million miles.

7. How far apart must the two lines given in (6) be placed that the distance between them may bear a proper relation to the respective diameters of the earth and the sun?

8. The sun being so much larger than the earth, if the latter were flat, what would be the facts about the forenoon, noon, and the afternoon on different parts of the earth?

9. What facts do you know to actually exist concerning sunrise, forenoon, noon, afternoon, and sunset on different parts of the earth?

10. Telegraphic communication now makes it possible for us to read in the daily papers of an event that has taken place in Europe on the same day, but, according to our clocks, at an *earlier* hour than that at which the event occurred. That is, we may read at eight or nine o'clock A. M. about what is said

to have occurred at twelve, noon. Clocks indicate indirectly the position of the sun in the heavens, and it follows, from the foregoing, that when the sun is at the zenith at one place it is much nearer the horizon at another. The newspaper reports show, respecting two places, one west the other east, that at the same moment the sun will be nearer the eastern horizon at the former place than the latter; also, that it is possible for two persons to be so situated that the one in the east may see the sun in the zenith while the other may see it at the same time on his eastern horizon.

11. What is the relation to each other of the *lines of vision* of the two persons who thus see the sun, one in the zenith, one on the horizon?

12. What is the supposition that can be made that will explain the fact? Can it be explained by more than one supposition?

13. When one ascends an elevation, how does the horizon line change? Can this be explained by more than one supposition?

14. What conclusion can be drawn from the foregoing study respecting the shape of the earth?

II. CONCERNING THE SLANT OF THE SUN'S RAYS.

1. What is the relation, *to each other*, of the shortest rays of light and heat that fall from the sun upon the lighted area of the earth?

2. If the earth were flat, since the sun is larger than the earth, upon what would the degree of slant of the rays depend?

3. If the earth were flat, what would be the

relation between the degrees of slant on different parts of the earth?

4. From what was learned under I, Topic 10, what must be true concerning the degree of slant on different parts of the earth within the lighted area?

5. What is the relation, *to the earth*, of the rays that strike the central point of the lighted area?

6. What is the relation, *to the earth*, of the rays that strike the extreme border of the lighted area?

7. What supposition respecting the surface of the earth will account for the facts about the slant of the rays?

III. CONCERNING THE EARTH'S MOTIONS.

A. Rotation.

1. Supposing the earth to be stationary, as it seems to be, what movement must the sun perform in order to produce day and night?

2. The sun being distant ninety-three million miles, how far would it have to travel to produce a day and a night?

3. In what time would the sun have to travel the distance necessary to produce a day and a night? How far in one hour? How far in one second?

(*c*) *Statement.* The sun, in its relation to the earth, may be regarded as being stationary.

4. What supposition can you make that will explain the occurrence of day and night?

5. The earth's circumference is twenty-five thousand miles; how far must a given point on the equator move during the time of one day and night? How far in one hour? In one second?

6. If the earth were stationary, from appearances, what would be the truth respecting not only the sun but all the stars near and remote?

7. Which supposition explains the appearances in the simpler manner?

B. Revolution.

1. The sun being regarded as stationary, what movements of the earth can you imagine which will give to the sun its apparent movement on the meridian in the course of a year?

2. Imagine a tipping of the north pole toward the sun during six months and a tipping away from it during the remaining six months; what would be the apparent motion of the sun during that time?

3. Imagine the earth with a *pivotal* motion on the south pole—a wabbling motion like that of a dying top; how would the sun appear to move?

(*d*) *Statement.* The north star may be regarded as a fixed star.

4. If the earth tipped or wabbled, what would be apparently true of the north star in each case?

5. With these facts in mind, what possible supposition can be made respecting the earth's motion which will account for the apparent movement of the sun on the meridian, with the consequent change of seasons, and the stationary appearance of the north star.

6. In addition to the supposed motion of the earth, what other facts must be associated with it in order to fully explain what has been mentioned in the previous question?

IV. Concerning the Variation of Light and Heat Received from the Sun During the Year.

Procure a scantling about fifteen centimeters square, one meter long, and square the ends. Fasten one end of this by means of a hinge to a heavy board, about thirty centimeters wide and two meters long, so that the scantling may be moved back and forth from a perpendicular to a horizontal position. Fasten the board solidly to the ground, in the school yard, on a *north and south line* with the free end of the scantling to the south. Attach to one side of the scantling a small brass protractor with its straight edge either at *right angles to* or *parallel with* the upper surface. From the center of the arc, suspend a shot or bullet by a thread, and it, hanging vertically, will indicate the degree of slant which the scantling may have. As soon as practicable, after the opening of the school year, on a day when the sun is shining, and when it is on the meridian, support the scantling by means of a block underneath so that *it will cast a shadow from its cross section only.* It is evident that it will then have the same slant as the sun's rays; and if we regard the stick of wood as representing a given volume or beam of sunlight and heat, it is clear that the area of the shadow cast by the cross section is equal to the area covered by this volume of sunlight and heat. Read the angle of elevation of the sun at this time, and mark and measure the area of the shadow cast on the board. From week to week, by moving the supporting block back,

the scantling can be readjusted to the changing slant, and the different areas covered by the same volume of light and heat, as the season advances, may be measured and compared. By this means it will be shown that as the sun moves down the meridian, and as the days become shorter, a given volume of light and heat is distributed over a larger space, and consequently its effects will be less upon any portion of that area. The apparatus, here described, will not only show this fact, but it will furnish a means for comparatively accurate measurement in which the area of the cross section of the stick, representing the area covered by this volume of rays when vertical, may be used as a convenient standard.

PROBLEMS.

I. WHOLE NUMBERS.

1. What was the decrease in the day's length during the first week? During the second? During the third? During the fourth?

2. What was the total decrease in the day's length during the month?

3. How many minutes did the day lose during each week at evening? During the entire month?

4. How many minutes did the day lose during each week in the morning? During the entire month?

5. During which week did the day lose most, and how much? During which the least, and how much?

6. What is the difference between the loss in the first week and the loss in the last week of the month?

7. What is the difference between the length of the day and the length of the night at the beginning of the month? At the end of the month?

8. How many degrees did the sun move down the meridian during the first week? During the second? During the third? During the fourth?

9. How many degrees did the sun move on the meridian during the month?

10. What is the area of the shadow cast at the beginning of the first week by the shadow-stick described on a previous page?

11. What difference in area between the shadow measured first and that cast a week later? Two weeks later? Three weeks later?

II. FRACTIONS.

1. What part of the day's length was lost during the first week? During the second? During the third? During the fourth?

2. What part of the day's length was lost during the month?

3. What part of the loss during the first week was in the morning? During the second week? During the third week? During the fourth week?

4. What part of the entire loss during the month was in the morning? What part was in the evening?

5. What part of the loss in the evening equals the loss in the morning?

6. The number of degrees the sun has moved on the meridian during the month equals what part of the distance from the horizon to the zenith?

7. What part of the distance traversed on the meridian during the month did the sun move during the first week? During the second? During the third? During the fourth?

8. The distance the sun is above the southern horizon at noon, when the day and night are equal, is what part of the distance from the horizon to the zenith?

9. The area of the cross section of the shadow-stick, described on a previous page, is what part of the area of the shadow cast the first of the month?

10. The area of the shadow cast at the beginning of the first week is what part of the area cast at the beginning of the second? The third? The fourth?

III. RATIO.

1. What is the ratio of the loss of the day's length during the first week to the loss during the second? To the loss during the third? To the loss during the fourth?

2. What is the ratio of the loss occurring in the morning during each week to the total loss in the day's length for the same time?

3. What is the ratio of the loss during the evening of each week to the total loss in the day's length for the same time?

4. What is the ratio of the loss of day's length in the morning during each week to the loss at evening for the same time?

5. What is the ratio of the average of the day's length during the first week to the average length

of the night? During the second week? During the third week?

6. What is the ratio of the average of the day's length during the month to the average length of night?

7. What is the ratio of the average length of day during the first week to the average length during the second week? To the average length of day in the third week? To the average length in the fourth week?

8. What is the ratio of the length of night at the beginning of the month to the length of night at the end of the month?

9. What is the ratio of the day's length at the beginning, to its length at the end of the month?

10. What is the ratio of the day's length at the beginning of the month to the length of the night at the same time?

11. What is the ratio of the length of the day at the end of the month to the length of the night at the same time?

12. What is the ratio of the area of the cross section of the shadow-stick, described on a previous page, to the area of the shadow it cast at the beginning of the first week?

13. What is the ratio of the area of the shadow measured the first week to that measured the second? The third? The fourth?

IV. PERCENTAGE.

1. What per cent of the day's length is lost during the first week of the month? What per

cent during the second week? During the third week? During the fourth week?

2. What per cent of the day's length is lost during the first week in the morning? During the second week? During the third week? During the fourth week?

3. What per cent of the loss of the day's length during the month occurs in the morning?

4. What per cent of the loss of the day's length for the month occurs in the evening?

5. What per cent of the day's length is lost during the month?

6. The length of the night at the end of the month is what per cent of its length at the beginning?

7. The length of the day at the end of the month is what per cent of its length at the beginning?

8. At the beginning of the month, the length of the day is what per cent of the length of the night?

9. The length of the day is what per cent of the length of the night at the end of the month?

10. The area of the cross section of the shadow-stick, described on a previous page, is what per cent of the area of the shadow measured the first week?

11. The area of the shadow measured the first week is what per cent of that measured the second? The third? The fourth?

GEOGRAPHY.

NORTH AMERICA—COAST LINES AND RELIEF.

In order to obtain the data required for the solution of the problems given in geography, it will be necessary to have access to reliable sources of geographical information. By sending to the nearest Weather Bureau Station, the teacher may procure, gratis, various maps and monthly summaries which will be of the greatest service. With these and a good physical geography, such as Guyot's, containing maps and tables of areas, hights, lengths of rivers, coast line, etc., all the work may be done. The problems have been given with a view to assisting the pupil to form definite and clear concepts of the physical features, with their relations to each other, and of the phenomena of climate which underlie and, to so large an extent, control the political, commercial, and social life of the people. Lack of imagination is the great obstacle which stands in the way of pupils in the study of geography. It is not enough that one knows that the Mississippi River, for example, flows through a valley, but he must know something definite about the extent of the valley, and its relations to other similar areas adjacent to it. Stimulated by his observations on the country about him, the

pupil must be taught to use his imagination in a rational manner concerning those parts of the country which lie beyond the range of his observation.

PROBLEMS.

I. WHOLE NUMBERS.

A. Coast Lines.

1. Which is the longer, and how much, the Atlantic or the Pacific coast?

2. Which is the longer, and how much, the Atlantic or the Arctic coast?

3. Which is the longer, and how much, the Atlantic or the Gulf coast?

4. Which is the longer, and how much, the Arctic or the Gulf coast?

5. Which is the longer, and how much, the Arctic or the Pacific coast?

6. Which is the longer, and how much, the Gulf or the Pacific coast?

7. What is the total length of coast line of North America?

8. For every hundred square miles of area how much coast line has North America?

B. Relief.

Guyot gives the following classification of relief forms:

ELEVATIONS IN MASS.—*Plains or lowlands: altitude less than one thousand feet.*

Alluvial: formed by river overflow.

Marine: sandy, formed under sea water.

Undulating: intermediate between marine and alluvial; rolling.

Plateaus or table-lands: altitude over one thousand feet.

Plateaus of the first order: altitude over eight thousand feet.

Plateaus of the second order: altitude from four thousand to eight thousand feet.

Plateaus of the third order: altitude from one thousand to four thousand feet.

LINEAR ELEVATIONS.—*Mountains: altitude over two thousand feet. Hills: altitude less than two thousand feet.*

9. Which is greater, and how much, the area of table-lands or the area of plains in North America?

10. Which is greater, and how much, the area of the plateaus of the third order or the area of those of the second? The third or the first?

11. Which is greater, and how much, the area of alluvial plains or the area of marine plains?

12. Which is greater, and how much, the area of alluvial plains or the area of undulating plains?

13. Which is greater, and how much, the area of the marine or the area of the undulating plains?

14. Which is greater, and how much, the area of the plains or the area of the plateaus of the third order?

15. Which has the greater plain area, and how much, the northern half of the continent or the southern? The eastern or the western?

16. Which has the greater plateau area, and how much, the northern half or the southern? The eastern or western?

17. Which is greater, and how much, the area of the Pacific highland or that of the Atlantic highland?

18. Which is greater in length, and how much, the length of the Rocky Mountain system or that of the Appalachian?

19. Which is greater, and how much, the average elevation of the Rocky Mountains or that of the Appalachian?

20. How much higher than the average elevation of the system is the highest peak in the Rocky Mountains?

21. How much higher than the average elevation of the system is the highest peak in the Appalachian Mountains?

22. How much difference in hight is there between the loftiest peak in the Rocky Mountains and the loftiest peak in the Appalachian system?

II. FRACTIONS.

A. Coast Line.

1. The length of the Atlantic coast is what part of the length of the Pacific coast?

2. The length of the Gulf coast is what part of the length of the Atlantic coast?

3. The length of the Atlantic coast is what part of the length of the Arctic coast?

4. The length of the Gulf coast is what part of the length of the Arctic coast?

5. The length of the Gulf coast is what part of the length of the Pacific coast?

6. The length of the Arctic coast is what part of the length of the Pacific coast?

7. The length of the Atlantic coast is what part of the length of the coast line of the entire continent?

8. The length of the Arctic coast line is what part of the length of the coast line of the entire continent?

9. The length of the Gulf coast is what part of the length of the coast line of the entire continent?

10. The length of the Pacific coast is what part of the length of the coast line of the entire continent?

11. For every square mile of area, what part of a mile of coast line in North America?

B. Relief.

12. The area of the plains is what part of the area of the plateaus?

13. The area of the alluvial plains is what part of the total plain area?

14. What part of the plain area is the area of the marine plains?

15. What part of the entire plain area is the area of the undulating plains?

16. The area of the alluvial plains is what part of the area of the marine plains?

17. The area of the alluvial plains is what part of the area of the undulating plains?

18. The area of the marine plains is what part of the area of the undulating plains?

19. The area of the plains is what part of the area of the plateaus of the third order? Of the second? Of the first?

20. The area of the plateaus of the second order is what part of the area of those of the first order?

21. The length of the Appalachian Mountain system is what part of that of the Rocky Mountain system?

22. The average hight of the Rocky Mountains is what part of the hight of the highest peak?

23. The average hight of the Appalachian Mountains is what part of the hight of the highest peak?

24. The average hight of the Appalachian Mountains is what part of the average hight of the Rocky Mountains?

25. The hight of the highest peak in the Appalachian Mountains is what part of the hight of the highest peak in the Rocky Mountains?

26. The highest part of the plateau in the western highland is what part of the average hight of the mountains?

27. The highest part of the plateau in the eastern highland is what part of the average hight of the mountains?

28. The average hight of the plateau in the eastern highland is what part of the average hight of that in the western highland?

III. RATIO.

A. Coast Lines.

1. The length of the Atlantic coast bears what ratio to that of the Pacific coast?

2. The length of the Gulf coast bears what ratio to that of the Atlantic coast?

3. The length of the Gulf coast bears what ratio to that of the Arctic coast?

4. The length of the Atlantic coast bears what ratio to that of the Arctic coast?

5. The length of the Gulf coast bears what ratio to that of the Pacific coast?

6. The length of the Arctic coast bears what ratio to that of the Pacific coast?

7. The length of the Atlantic coast bears what ratio to that of the entire continent?

8. The length of the Pacific coast bears what ratio to that of the entire continent?

9. The length of the Gulf coast bears what ratio to that of the entire continent?

10. The length of the Arctic coast bears what ratio to that of the entire continent?

11. The number of square miles of area bears what ratio to the number of miles of coast line?

12. What is the ratio of the actual area of the continent to the area which its coast line might enclose?

B. Relief.

13. What is the ratio of the plain area to the plateau area?

14. What is the ratio of the alluvial plain area to the total plain area?

15. What is the ratio of the marine plain area to the total plain area?

16. What is the ratio of the undulating plain area to the total plain area?

17. What is the ratio of the alluvial plain area to the marine plain area?

18. What is the ratio of the alluvial plain area to the undulating plain area?

19. What is the ratio of the marine plain area to the undulating plain area?

20. What is the ratio of the plain area to that of the plateaus of the third order?

21. What is the ratio of the area of the plateaus of the second order to that of the first?

22. What is the ratio of the area of the plateaus of the third order to the entire plateau area?

23. What is the ratio of the area of the plateaus of the second order to the entire plateau area?

24. What is the ratio of the length of the Appalachian Mountain system to that of the Rocky Mountain system?

25. What is the ratio of the average hight of the Rocky Mountain system to that of the highest peak?

26. What is the ratio of the average hight of the Appalachian Mountain system to that of the highest peak?

27. What is the ratio of the hight of the highest peak in the Appalachian system to that of the highest peak in the Rocky Mountain system?

28. What is the ratio of the average hight of the Appalachian Mountain system to the average hight of the Rocky Mountain system?

29. What is the ratio of the greatest hight of the plateau to the average elevation of the mountains in the western highland?

30. What is the ratio of the greatest hight of the plateau in the eastern highland to the average elevation of the mountain chains?

31. The greatest hight of the eastern plateau bears what ratio to the greatest hight of the western?

32. What is the ratio of the greatest hight of plateau in the western highland to the hight of the highest peak?

33. What is the ratio of the greatest elevation of the plateau in the eastern highland to that of the highest mountain peak?

IV. PERCENTAGE.

A. Coast Line.

1. The length of the Atlantic coast is what per cent of that of the Pacific coast?

2. The length of the Gulf coast is what per cent of that of the Atlantic coast?

3. The length of the Gulf coast is what per cent of that of the Arctic coast?

4. The length of the Arctic coast is what per cent of that of the Atlantic coast?

5. The length of the Gulf coast is what per cent of that of the Pacific coast?

6. The length of the Arctic coast is what per cent of that of the Pacific coast?

7. The length of the Atlantic coast is what per cent of that of the entire continent?

8. The length of the Pacific coast is what per cent of that of the entire continent?

9. The length of the Arctic coast is what per cent of that of the entire continent?

10. The length of the Gulf coast is what per cent of that of the entire continent?

11. The number of square miles of actual area in North America is what per cent of that which could be enclosed by its length of coast?

12. The number of square miles of area is what per cent of the number of miles of coast line?

B. Relief.

13. The number of square miles in the plains equals what per cent of the number in the plateaus?

14. The number of square miles in the alluvial plains equals what per cent of the number in the entire plain area?

15. The number of square miles in marine plains equals what per cent of the number in the entire plain area?

16. The number of square miles in the undulating plain area equals what per cent of the entire plain area?

17. The number of square miles in the alluvial plain area equals what per cent of the number in the marine plains?

18. The number of square miles in the alluvial plain area equals what per cent of the number in the undulating plains?

19. The number of square miles in the marine plain area equals what per cent of the number in the undulating plain?

20. The number of square miles in the plain area equals what per cent of the number in the plateaus?

21. The number of square miles in the plateaus of the second order equals what per cent of the number in the third?

22. The number of square miles in the plateaus of the third order equals what per cent of the number in the entire plateau area?

23. The number of square miles in the plateau area equals what per cent of the number in the entire continent?

24. The number of square miles in the plains equals what per cent of the number in the entire continent?

25. The length of the Appalachian Mountain system equals what per cent of the length of the Rocky Mountain system?

26. The average elevation of the Appalachian Mountains equals what per cent of that of the Rocky Mountains?

27. The average elevation of the Rocky Mountains equals what per cent of the hight of the highest peak?

28. The average elevation of the Appalachian Mountains equals what per cent of the hight of the highest peak?

29. The elevation of the highest peak in the Appalachian Mountains equals what per cent of the hight of the highest peak in the Rocky Mountains?

30. The greatest plateau elevation in the western highland equals what per cent of the average elevation of the mountains?

31. The greatest plateau elevation in the eastern highland equals what per cent of the average hight of the mountains?

32. The greatest elevation of the plateau in the western highland equals what per cent of that of the highest peak?

33. The greatest elevation of the plateau in the eastern highland equals what per cent of that of the highest peak?

MINERALOGY.

THE MECHANICAL CONSTITUENTS OF SOILS.

The following lessons are intended to accompany geography work on the subject of erosion, transportation and deposition of soils. In making the required analysis two small sieves about eight centimeters square and three centimeters deep will be required; the first to have wire gauze with one-tenth-inch mesh and the second with gauze one-fiftieth of an inch mesh. In addition to these a tall bottle or jar will be required. To gather the necessary data, proceed as follows:

1. Select a sample of soil of average composition and dry it.

2. Rub up the lumps and pass a definite amount —about twenty grams—through the coarse sieve. Wash, dry, and weigh the part too coarse to pass through and this will give the *coarse gravel.*

3. Rub the part which passed through the coarse sieve through the fine sieve. Wash, dry, and weigh the part too coarse to pass through and this will give the *gravelly sand.*

4. Weigh a definite amount of the *gravelly sand* and heat it red hot in a Battersea dish; the loss will be the weight of *organic matter.*

5. Weigh a definite amount—about fifteen grams—of the *gravelly sand* and separate the particles by shaking or boiling in a flask; rinse it out into a tall jar with a wide mouth. Set the jar in a larger vessel to catch the overflow and then by means of a gentle stream of water and agitation wash until the water runs away clear. Dry and weigh what remains, and this will be the *coarse sand.* Heat a definite amount of this in a Battersea dish to find the *organic matter.*

6. Repeat the process described in (5) with the overflow with less agitation and the result will be the *fine sand.* Heat as before for the *organic matter.*

7. Subtract the weight of the *coarse* and *fine* sand from the weight taken in the beginning and the result will be the *clay* in the soil.

The several steps employed in mechanical analysis are here given, but with pupils beginning the work not so much should be attempted. The teacher must determine how much can be intelligently done by the pupils.

These operations will furnish the following data:

1. The coarse gravel.
2. The gravelly sand.
3. The organic matter.
4. The coarse sand.
5. The fine sand.
6. The clay.

PROBLEMS.

I. WHOLE NUMBERS.—(*Use from twenty-five to fifty grams.*)

1. Which weighs more, and how much, the coarse gravel or the gravelly sand?

2. Which weighs more, and how much, the coarse gravel or the organic matter?

3. Which weighs more, and how much, the coarse gravel or the coarse sand?

4. Which weighs more, and how much, the coarse gravel or the fine sand?

5. Which weighs more, and how much, the coarse gravel or the clay?

6. Which weighs more, and how much, the gravelly sand or the organic matter?

7. Which weighs more, and how much, the gravelly sand or the coarse sand?

8. Which weighs more, and how much, the gravelly sand or the fine sand?

9. Which weighs more, and how much, the gravelly sand or the clay?

10. Which weighs more, and how much, the organic matter or the coarse sand?

11. Which weighs more, and how much, the organic matter or the fine sand?

12. Which weighs more, and how much, the organic matter or the clay?

13. Which weighs more, and how much, the coarse sand or the fine sand?

14. Which weighs more, and how much, the coarse sand or the clay?

15. Which weighs more, and how much, the fine sand or the clay?

II. Fractions.

1. What part of the weight of the soil is the weight of the coarse sand?

2. What part of the weight of the soil is the weight of the gravelly sand?

3. What part of the weight of the soil is the weight of the organic matter?

4. What part of the weight of the soil is the weight of the fine sand?

5. What part of the weight of the soil is the weight of the clay?

6. The weight of the coarse gravel is what part of the weight of the gravelly sand?

7. The weight of the organic matter is what part of the weight of the clay?

8. The weight of the organic matter is what part of the weight of the fine sand?

9. The weight of the organic matter is what part of the weight of the coarse sand?

10. The weight of the organic matter is what part of the weight of the clay? Of the fine sand? Of the coarse sand?

11. The weight of the clay is what part of the weight of the fine sand? Of the coarse sand? Of the organic matter?

12. The weight of the fine sand is what part of the weight of the coarse sand?

13. The weight of the fine sand is what part of the weight of the gravelly sand?

14. The weight of the coarse sand is what part of the weight of the gravelly sand and coarse gravel?

15. The weight of the coarse gravel is what part of the weight of the gravelly sand? Of the coarse sand? Of the fine sand?

III. RATIO.—(*By weight.*)

1. What is the ratio of the coarse gravel to the soil?

2. What is the ratio of the gravelly sand to the soil?

3. What is the ratio of the organic matter to the soil?

4. What is the ratio of the coarse sand to the soil?

5. What is the ratio of the fine sand to the soil?

6. What is the ratio of the clay to the soil?

7. What is the ratio of the coarse gravel to the gravelly sand?

8. What is the ratio of the coarse gravel to the organic matter?

9. What is the ratio of the coarse gravel to the coarse sand?

10. What is the ratio of the coarse gravel to the fine sand?

11. What is the ratio of the coarse gravel to the clay?

12. What is the ratio of the gravelly sand to the organic matter?

13. What is the ratio of the gravelly sand to the coarse sand?

14. What is the ratio of the gravelly sand to the fine sand?

15. What is the ratio of the gravelly sand to the clay?

16. What is the ratio of the organic matter to the coarse sand?

17. What is the ratio of the organic matter to the fine sand?

18. What is the ratio of the organic matter to the clay?

19. What is the ratio of the coarse sand to the fine sand?

20. What is the ratio of the coarse sand to the clay?

21. What is the ratio of the fine sand to the clay?

IV. PERCENTAGE.—(*By weight.*)

1. The coarse gravel equals what per cent of the soil?

2. The gravelly sand equals what per cent of the soil?

3. The organic matter equals what per cent of the soil?

4. The coarse sand equals what per cent of the soil?

5. The fine sand equals what per cent of the soil?

6. The clay equals what per cent of the soil?

7. The clay equals what per cent of the fine sand?

8. The clay equals what per cent of the coarse sand?

9. The clay equals what per cent of the organic matter?

10. The clay equals what per cent of the fine sand? Of the coarse sand? Of the gravelly sand?

11. The fine sand equals what per cent of the coarse sand? Of the gravelly sand? Of the coarse gravel?

12. The coarse sand equals what per cent of the gravelly sand? Of the coarse gravel? Of the fine sand?

13. The organic matter equals what per cent of the fine sand? Of the coarse sand? Of the clay?

14. The gravelly sand equals what per cent of the coarse sand and fine sand?

15. The coarse gravel equals what per cent of the gravelly sand? Of the coarse sand? Of the fine sand?

16 The coarse gravel and gravelly sand equal what per cent of the soil?

ZOÖLOGY.

STUDY OF ANIMAL TISSUES.

It is usually given to pupils, as a matter of information, that bone and other animal tissues are composed of animal and mineral, that is, of organic and inorganic matter. It is not very difficult to have pupils perform certain experiments which will show in definite results the approximate amount of the different constituents. The following problems have been prepared with respect to bone and muscle, but they may be adapted to the study of any other tissue. For the purpose of the study, secure some small pieces of well-bleached bone and pound or grind them up rather fine. Weigh a small amount — about five grams—and place in a battersea dish over the alcohol or bunsen flame. When reduced to a fine grayish white ash weigh again and note the loss. This will give the following data:

1. Weight of the dried or bleached bone.
2. Weight of organic matter; this is the weight lost by burning.
3. Weight of ash or inorganic matter.

The periosteum and adhering fat may be cleaned from a fresh bone and a small piece, after being dried, may be weighed. By soaking this in dilute hydrochloric acid the mineral matter will be removed.

When soft and flexible the part remaining should be thoroughly dried and weighed. This will give the amount of organic matter in the fresh bone. The difference between this and the weight of the fresh bone will give the weight of the inorganic matter which was removed by the acid.

PROBLEMS.

I. WHOLE NUMBERS.

1. How much greater is the weight of the dry bone than the weight of the ash it contains?

2. How much greater is the weight of the dry bone than the weight of the organic matter it contains?

3. Which is greater, and how much, the weight of the organic matter or the weight of the ash?

4. The weight of the organic matter obtained by soaking the bone in acid is how much less than that of the fresh bone?

5. The weight of the mineral matter lost by soaking the bone in acid is how much less than the weight of the fresh bone?

6. The weight of the mineral matter lost by soaking the bone in acid is how much less than the weight of the organic matter?

7. What is the difference between a given weight of a piece of muscle and the weight of the ash it contains?

8. What is the difference between a given weight of a piece of muscle and the weight of the organic matter in it?

9. Which is greater in weight, and how much,

the ash in a bone or the ash in a piece of muscle of equal weight?

10. Which is greater in weight, and how much, the organic matter in a bone or the organic matter in a piece of muscle of equal weight?

II. FRACTIONS.

1. The weight of the ash equals what part of the weight of the entire bone?

2. The weight of the ash equals what part of the weight of the organic matter?

3. The weight of the organic matter equals what part of the weight of the entire bone?

4. The weight of the organic matter equals what part of the weight of the ash?

5. The weight of the entire bone equals what part of the weight of the ash?

6. The weight of the entire bone equals what part of the weight of the organic matter?

7. The weight of a human skeleton is twenty-four pounds; what part of the weight of an average man is it?

8. What is the weight of ash in a human skeleton of twenty-four pounds' weight?

9. What is the weight of organic matter in a human skeleton of twenty-four pounds' weight?

10. The weight of ash in the skeleton is what part of the weight of an average man?

11. The weight of organic matter in a skeleton is what part of the entire weight of an average man?

12. What part of the weight of muscle is the weight of the ash which it contains.

13. What part of the weight of muscle is the organic matter which it contains?

14. The weight of the ash equals what part of the weight of the organic matter in a piece of muscle?

15. The ash found in a given weight of muscle equals what part of that found in the same weight of bone?

16. The organic matter found in a given weight of muscle equals what part of that found in the same weight of bone?

17. The muscle forms forty-two hundredths of a man's weight; how much ash does it contain?

18. How much organic matter in the muscles of an average-sized man?

III. RATIO.

1. What is the ratio, by weight, of the ash to the entire bone?

2. What is the ratio, by weight, of the ash to the organic matter?

3. What is the ratio, by weight, of the organic matter to the entire bone?

4. What is the ratio, by weight, of the organic matter to the ash?

5. What is the ratio, by weight, of the entire bone to the organic matter it contains?

6. What is the ratio, by weight, of the entire bone to the ash it contains?

7. The weight of a human skeleton is twenty-four pounds; what weight of ash does it contain? What weight of organic matter?

8. What is the ratio, by weight, of the ash in the skeleton to the average weight of a man?

9. What is the ratio, by weight, of the organic matter in the skeleton to the average weight of a man?

10. What is the ratio, by weight, of the skeleton to the average weight of a man?

11. What is the ratio, by weight, of the ash in muscle to the entire weight of the muscle?

12. What is the ratio, by weight, of the organic matter in muscle to the entire weight of the muscle?

13. What is the ratio, by weight, of the ash in muscle to the organic matter which it contains?

14. What is the ratio, by weight, of the ash found in muscle to the ash found in bone?

15. What is the ratio, by weight, of the organic matter found in muscle to the organic matter found in bone?

16. The muscles form forty-two hundredths of the entire weight of man; how much ash, by weight, does this amount of muscle contain?

17. How much organic matter, by weight, in the muscles of an average man?

IV. PERCENTAGE.

1. What per cent, by weight, is the ash of the entire bone?

2. What per cent, by weight, is the ash of the organic matter in bone?

3. What per cent, by weight, is the organic matter of the entire bone?

4. What per cent of the weight of the organic matter equals the weight of the ash?

5. The weight of a human skeleton is twenty-four pounds; how much ash, by weight, does it contain? How much organic matter?

6. What per cent of an average man's weight is his skeleton?

7. What per cent of an average man's weight is the ash in his skeleton?

8. What per cent of an average man's weight is the organic matter in the skeleton?

9. What per cent of a given weight of muscle equals the weight of the ash?

10. What per cent of a given weight of muscle equals the weight of the organic matter?

11. The ash in muscle equals what per cent, by weight, of the organic matter?

12. The ash found in a given weight of muscle equals what per cent of that found in the same weight of bone?

13. The organic matter found in muscle equals what per cent, by weight, of that found in the same weight of bone?

14. The muscles form forty-two hundredths of a man's weight; how much ash in an average man's muscle?

15. How much organic matter in an average man's muscle?

BOTANY.

ANNUAL GROWTH OF BRANCHES OF TREES.

The motive for the following lessons is to lead the pupil to investigate the laws of growth which prevail in different trees by which their forms are determined. Each kind of tree, when uninfluenced by accidental surroundings, seems to grow according to a certain type form from which individuals vary but little. Why a certain typical form should be found to include the greater number of the individuals of a particular kind of tree is a question not easily answered. Knowing, however, the functions of the leaf in its two-fold capacity as lungs and stomach, and, for the proper performance of these functions, its dependence upon sunlight and air, it is fair to conclude that the growth and distribution of branches is such as will insure the greatest exposure of leaf surface to these influences. Many other factors enter into the problem, such as the angle the branches make with the main stem, the shape and arrangement of the leaves, the relation of the terminal to the lateral growth, and the relation of the dormant to the active buds. Some of these will be considered in another place. When the type form of a tree is discovered, the general symmetry of the tree within

the general form is the most striking feature; yet closer observation will reveal more or less asymmetry, so that the different sides of the tree may be considered as measures, relatively, of the different influences or forces which play upon them and upon the tree as a whole. The results should thus indicate something of the mutual relations of the tree and its environment.

It is intended that the following observations and measurements should be made:

1. As large a number of measurements as practicable of the terminal growths on each side of the tree.

2. Similar measurements of the growths from lateral buds.

3. The length of the terminal and lateral growths of one or more of the preceding years, taken from each side of the tree.

4. The measurement of the greatest spread of branches; hold a plumb line under the end of the longest branch and measure on the ground the distance from the line to the trunk.

PROBLEMS.

I. WHOLE NUMBERS.

A. The present year.

1. What is the average length of the growths from the terminal buds on the north side of the tree?

2. What is the average length of the growths from the lateral buds on the north side of the tree?

3. What is the average length of the growths from the terminal buds on the south side of the tree?

4. What is the average length of the growths from the lateral buds on the south side of the tree?

5. What is the average length of the growths from the terminal buds on the east side of the tree?

6. What is the average length of the growths from the lateral buds on the east side of the tree?

7. What is the average length of the growths from the terminal buds on the west side of the tree?

8. What is the average length of the growths from the lateral buds on the west side of the tree?

9. Which side of the tree had the greatest average terminal growth, and how much?

10. Which side of the tree had the greatest average lateral growth, and how much?

11. Which is the greater, and how much, the average terminal growth or the average lateral growth on each side of the tree?

12. Which is the greater, and how much, the average terminal growth or the average lateral growth on the entire tree?

13. What is the horizontal distance from the trunk through which the longest branch extends on the north side of the tree?

14. What is the horizontal distance from the trunk through which the longest branch extends on the south side of the tree?

15. What is the horizontal distance from the trunk through which the longest branch extends on the east side of the tree?

16. What is the horizontal distance from the trunk through which the longest branch extends on the west side of the tree?

17. What is the difference between the length of the longest branch on the north side of the tree and the length of the longest branch on the south side? Compare those on the east and west sides.

B. The preceding year.—(Note whether or not the tree has reached its maturity.)

18. Which is greater, and how much, the average terminal growth or the average lateral growth on the north side?

19. Which is greater, and how much, the average terminal growth or the average lateral growth on the south side?

20. Which is greater, and how much, the average terminal growth or the average lateral growth on the east side?

21. Which is greater, and how much, the average terminal growth or the average lateral growth on the west side?

22. In which year was the terminal growth greater on each side; how much greater was it?

23. In which year was the lateral growth greater on each side; how much greater was it?

24. Which of the following has the greatest average terminal growths, and how much, the maple, the willow, the oak, the ash, the box-elder, the elm?

25. Which of the following has the greatest average lateral growths, and how much, the maple, the willow, the oak, the ash, the box-elder, the elm?

II. FRACTIONS.

A. The present year.

1. The average growth of the twigs on the north side of the tree from the lateral buds equals what part of the average growth from the terminal buds?

2. The average growth of the twigs on the south side of the tree from the lateral buds equals what part of the average growth from the terminal buds?

3. The average growth of the twigs on the east side of the tree from the lateral buds equals what part of the average growth from the terminal buds?

4. The average growth of the twigs on the west side of the tree from the lateral buds equals what part of the average growth from the terminal buds?

5. The average terminal growth on the north side equals what part of the average terminal growth on the south side?

6. The average lateral growth on the north side equals what part of the average lateral growth on the south side?

7. The average terminal growth on the east side equals what part of the average terminal growth on the west side?

8. The average lateral growth on the east side equals what part of the average lateral growth on the west side?

9. The average lateral growth of the twigs on

the entire tree equals what part of the average terminal growth of the twigs?

10. The horizontal distance through which the longest branch on the north side of the tree extends from the trunk equals what part of the distance through which the longest branch extends on the south side?

11. The horizontal distance through which the longest branch on the east side of the tree extends from the trunk equals what part of the distance through which the longest branch extends on the west side?

12. The horizontal distance through which the longest branch extends on the north side of the tree equals what part of the distance through which the longest branch extends on the east side? Compare the west side.

13. The horizontal distance through which the longest branch extends on the south side of the tree equals what part of the distance through which the longest branch extends on the east side? Compare the west side.

14. The average terminal growth on the north side of the tree equals what part of the average terminal growth on the east side? On the west side?

15. The average lateral growth on the north side of the tree equals what part of the average lateral growth on the east side? On the west side?

16. The average terminal growth on the south side of the tree equals what part of the average

terminal growth on the east side? On the west side?

17. The average lateral growth on the south side of the tree equals what part of the average lateral growth on the east side? On the west side?

B. The preceding year.—(Note whether or not the tree has reached its maturity.)

18. The average terminal growth on each side of the tree equals what part of the average terminal growth for the present year?

19. The average lateral growth on each side of the tree equals what part of the average lateral growth for the present year?

20. The average terminal growth for the entire tree equals what part of the average terminal growth for the present year?

21. The average lateral growth for the entire tree equals what part of the average lateral growth for the present year?

22. The average terminal growth of the oak equals what part of the average terminal growth of the maple? Of the ash? Of the willow? Of the box-elder? Of the elm?

23. The average lateral growth of the oak equals what part of the average lateral growth of the maple? Of the ash? Of the willow? Of the box-elder? Of the elm?

24. The length of the greatest horizontal diameter of the top of the oak equals what part of the length of the vertical diameter of the top?

25. Compare as in (24) the two diameters of the ash, the maple, the box-elder, and the elm?

III. RATIO.

A. The present year.

1. The average growth of the lateral twigs on the north side of the tree bears what ratio to the average growth of the terminal twigs on the same side?

2. What is the ratio of the average growth of the twigs from the lateral buds on the south side of the tree to the average growth from the terminal buds on the same side?

3. What is the ratio of the average growth of the lateral twigs on the east side of the tree to the average growth of the terminal twigs on the same side?

4. What is the ratio of the average growth of lateral twigs on the west side of the tree to the average growth of the terminal twigs on the same side?

5. What is the ratio of the average length of the terminal twigs on the north side of the tree to the average length of the terminal twigs on the south side?

6. What is the ratio of the average length of the lateral twigs on the north side of the tree to the average length of the lateral twigs on the south side?

7. What is the ratio of the average length of the terminal twigs on the east side of the tree to the average length of the terminal twigs on the west side?

8. What is the ratio of the average length of the lateral twigs on the east side of the tree to the

average length of the lateral twigs on the west side?

9. What is the ratio of the average length of the lateral growths of the entire tree to the average length of the terminal growths?

10. What is the ratio of the average length of the terminal growths on the north side of the tree to the average length of the terminal growths on the east side? On the west side?

11. What is the ratio of the average length of the lateral growths on the north side of the tree to the average length of the lateral growths on the east side? On the west side?

12. What is the ratio of the average length of the terminal twigs on the south side of the tree to the average length of the terminal twigs on the east side? On the west side?

13. What is the ratio of the average length of the lateral twigs on the south side of the tree to the average length of the lateral twigs on the east side? On the west side?

14. What is the ratio of the greatest horizontal distance from the trunk through which any branch extends on the north side of the tree to that through which any branch extends on the south side?

15. What is the ratio of the greatest horizontal distance from the trunk through which any branch extends on the east side of the tree to that through which any branch extends on the west side?

16. What is the ratio of the greatest horizontal distance from the trunk through which any branch

extends on the north side of the tree to that through which any branch extends on the east side? On the west side?

17. What is the ratio of the greatest horizontal distance through which any branch extends on the south side of the tree to that through which any branch extends on the east side? On the west side?

B. The preceding year.—(Note whether or not the tree has reached its maturity.)

18. What is the ratio of the average terminal growth of the twigs on each side of the tree to the average growth of terminal twigs for the present year?

19. What is the ratio of the average lateral growth of the twigs on each side of the tree to the average lateral growth for the present year?

20. The average terminal growth for the entire tree bears what ratio to the average terminal growth for the present year?

21. The average lateral growth for the entire tree bears what ratio to the average lateral growth of the entire tree for the present year?

22. The average terminal growth of the oak bears what ratio to the average terminal growth of the maple? The ash? The willow? The box-elder? The elm?

23. The average lateral growth of the oak bears what ratio to the average lateral growth of the maple? The ash? The willow? The box-elder? The elm?

IV. PERCENTAGE.

A. The present year.

1. The average growth of the twigs from the lateral buds on the north side of the tree equals what per cent of the average growth from the terminal buds on the same side?

2. The average growth of the twigs from the lateral buds on the south side of the tree equals what per cent of the average growth from the terminal buds on the same side?

3. The average growth of the twigs from the lateral buds on the east side of the tree equals what per cent of the average growth from the terminal buds on the same side?

4. The average growth of the twigs from the lateral buds on the west side of the tree equals what per cent of the average growth from the terminal buds on the same side?

5. The average terminal growth on the north side of the tree equals what per cent of the average terminal growth on the south side?

6. The average lateral growth on the north side of the tree equals what per cent of the average lateral growth on the south side?

7. The average terminal growth on the east side of the tree equals what per cent of the terminal growth on the west side?

8. The average lateral growth on the east side of the tree equals what per cent of the average lateral growth on the west side?

9. The average lateral growth over the entire tree equals what per cent of the terminal growth?

10. The average terminal growth on the north side of the tree equals what per cent of the average terminal growth on the east side? Of that on the west side?

11. The average lateral growth on the north side of the tree equals what per cent of the average lateral growth on the east side? Of that on the west side?

12. The average terminal growth on the south side of the tree equals what per cent of the average terminal growth on the east side? Of that on the west side?

13. The average lateral growth on the south side of the tree equals what per cent of the average lateral growth on the east side? Of that on the west side?

14. The greatest horizontal distance through which any branch extends on the north side of the tree equals what per cent of the distance through which any branch extends on the south side? The east side? The west side?

15. The greatest horizontal distance through which any branch extends on the east side of the tree equals what per cent of the distance through which any branch extends on the west side? The south side?

16. The greatest horizontal distance through which any branch extends from the trunk on the south side of the tree equals what per cent of that through which any branch extends on the west side?

B. The preceding year.—(*Note whether or not the tree has reached maturity.*)

17. The average terminal growth of the twigs on each side of the tree equals what per cent of the average terminal growth for the present year?

18. The average lateral growth on each side of the tree equals what per cent of the average lateral growth for the present year?

19. The average terminal growth of the entire tree equals what per cent of the average terminal growth for the present year?

20. The average growth of the lateral twigs over the entire tree equals what per cent of the average growth of the lateral twigs for the present year?

21. The average growth of the lateral twigs over the entire tree equals what per cent of the average growth of the terminal twigs?

22. The average terminal growth of the oak equals what per cent of the average terminal growth of the maple? Of the ash? Of the willow? Of the box-elder? Of the elm?

23. The average lateral growth of the oak equals what per cent of the average lateral growth of the maple? Of the ash? Of the willow? Of the box-elder? Of the elm?

THE DISTRIBUTION OF SEEDS.

The distribution of seeds is a most interesting and suggestive phase of plant life. It is the design, in the following study, to give the pupils from this standpoint a glimpse of the relation of the plant to its environment, and to show something of that great flexibility which the organism displays in adapting itself to its surroundings. In as large a collection as it is possible for the pupils to make conveniently, it is suggested that they look for the following classes:

1. The seeds that may be distributed by the wind by means of either sails, wings, or pappus.
2. The seeds that may be distributed by animals after having been eaten by them along with some other part of the fruit.
3. The seeds that are eaten as food when ripe.
4. The seeds that are stored as food for future use.
5. The seeds that may be distributed by being carried about in the hair or other covering of animals.
6. The seeds that are distributed by some structural contrivance of their own; as, in the case of the touch-me-not, by an elastic pod.
7. The seeds with no evident means of distribution.
8. The seeds about which the pupil is uncertain.

PROBLEMS.

I. WHOLE NUMBERS.

1. How many of your fruits are used as food by one or more different kinds of animals?

2. How many of your fruits are not eaten by any animal that you know?

3. How many of your fruits are devoured whole by animals?

4. How many of your fruits are eaten for the seeds which they contain? In how many kinds are the seeds totally destroyed by the animals?

5. In how many cases are the seeds devoured incidentally along with some other part of the fruit?

6. How many of your fruits are eaten by insects?

7. How many of your fruits are eaten by birds?

8. How many of your fruits are eaten by mammals?

9. How many of your fruits are eaten by all three of the above classes of animals?

10. How many different kinds have you that are stored up by animals for winter food?

11. How many different kinds can not be stored up for winter food?

12. How many different kinds of fruits have you that are not sought by animals for food?

13. How many different kinds of fruits have you found that are carried about in the wool, fur, or hair of animals being held by hooks or prickles?

14. How many of those that are carried about in the coverings of animals are used as food by animals?

15. How many fruits have you collected that have been stung by insects?

16. How many fruits have you collected that have no injuries whatever?

17. How many fruits have you collected that are provided with any means of protection against animal depredations?

18. How many fruits have you found that are distributed by the wind?

19. How many fruits have you found that are distributed by the wind that are eaten by animals? How many are in no wise interfered with by animals?

20. How many fruits have you found provided with wings or sails? How many have no appendages to assist directly in distribution?

21. Which is the greater, and how much, the number of fruits in your collection used in some way by animals, or the number not so used?

22. How many kinds of fruits have you that are thrown from the pod by some means when ripe?

23. How many different kinds of fruits can you find that will float in water?

24. How many different kinds of fruits can you find that will roll on sloping ground?

II. FRACTIONS.

1. What part of the entire number of fruits that you have gathered is used by animals as food?

2. What part of the entire number of fruits that you have gathered is not so used?

3. What part of the entire number of fruits that you have gathered is devoured whole?

4. What part of the entire number of fruits that you have gathered is devoured for the seeds they contain? What part is entirely destroyed when eaten?

5. What part of the entire number of fruits that you have gathered is eaten for the pulp or fleshy portion?

6. What part of the whole number of fruits that you have gathered is eaten by insects?

7. What part of the entire number of fruits that you have gathered is eaten by birds?

8. What part of the entire number of fruits that you have gathered is eaten by mammals?

9. What part of the entire number of fruits that you have gathered is eaten by all three classes of animals named above?

10. What part of the entire number of fruits that you have gathered is stored up for winter food by animals?

11. What part of the entire number of fruits that you have gathered can not be so stored for food?

12. What part of the entire number of fruits collected are carried about in animal coverings by means of hooks and prickles?

13. What part of the whole number of fruits provided with hooks and prickles is used for food?

14. What part of the entire number of fruits in your collection has been stung by insects?

15. What part of the entire number of fruits collected have not been injured in any way whatever by animals?

16. What part of the whole number of fruits in your collection is provided with some means of defense against animal depredations?

17. What part of the whole number of fruits collected is distributed by the wind?

18. What part of the entire number of fruits collected is provided with sails or wings? What part is without such appendages?

19. What part of the number of fruits distributed by the wind is eaten by animals?

20. What part of the entire number of fruits collected is thrown from the pod, by some means, when ripe?

21. What part of the entire number of fruits collected will roll on sloping ground?

22. What part of the entire number of fruits collected will float on water?

III. RATIO.

1. In the whole number of fruits you have gathered, what is the ratio of the number used by animals for food to the number not so used?

2. What is the ratio of the number of fruits devoured whole to the number of those that are broken up while being eaten?

3. What is the ratio of the number of fruits that are eaten for the seeds they contain to the number eaten for the pulp? What is the ratio of those in which the seeds are destroyed when eaten to the entire number?

4. What ratio does the number of fruits eaten by insects bear to the entire number collected?

5. What ratio does the number of fruits eaten by birds bear to the entire number collected?

6. What ratio does the number of fruits eaten by mammals bear to the entire number collected?

7. What is the ratio of the number of fruits eaten by insects alone to the number of fruits eaten by birds alone?

8. What is the ratio of the number of fruits that are stored for food to the number not so stored?

9 What is the ratio of the number of fruits and seeds that may be carried about in the coverings of animals to the number not thus distributed? What is the ratio to the entire number collected?

10. What is the ratio of the number of the fruits provided with hooks and prickles that are used as food to those of the same kind not so used?

11. What is the ratio of the number of fruits which you have that have been stung by insects to the number that are not so injured?

12. What ratio does the number of fruits that are provided with means of defense against animal depredations bear to the number that are not so provided?

13. What is the ratio of the number of fruits that you can find that are distributed by the wind to the number dependent upon animals for distribution?

14. What is the ratio of the number of fruits provided with sails or wings to the number not so provided?

15. What ratio does the number of fruits collected which have no obvious means for distribution

bear to the number provided with some means for this purpose?

16. What is the ratio of the number of kinds of seeds thrown from the pod when ripe to the whole number collected?

17. What is the ratio of the number that will roll on sloping ground to the entire number collected?

18. What is the ratio of the number that will float on water to the entire number?

IV. PERCENTAGE.

1. What per cent of the fruits that you have gathered are used as food by wild animals?

2. What per cent of the fruits that you have gathered are not used as food by wild animals?

3. What per cent of the fruits that you have collected are devoured whole

4. What per cent of the fruits that you have gathered are devoured for the seeds they contain? What per cent have the seeds destroyed when eaten?

5. What per cent of the fruits that you have gathered are devoured for the pulpy part?

6. What per cent of the fruits that you have gathered are eaten by insects? What per cent of the fruits that you have gathered are not touched by insects?

7. What per cent of the fruits that you have gathered are eaten by birds? What per cent are not eaten by birds?

8. What per cent of the fruits that you have gathered are eaten by mammals? What per cent *are not* eaten by mammals?

9. What per cent of the fruits that you have gathered are eaten in common by all the above-mentioned classes of animals?

10. What per cent of the fruits with which you are familiar are stored by animals as winter food? What per cent are not so stored?

11. What per cent of the entire number collected are carried about in the coverings of animals by hooks or prickles? What per cent can not be so carried?

12. What per cent of the number of fruits provided with hooks and prickles are used as food by wild animals? What per cent are not so used?

13. What per cent of the fruits collected have been stung by insects?

14. What per cent of the fruits collected have sustained no injuries from animals?

15. What per cent of the fruits collected are provided with some means of defense against animal depredations?

16. What per cent of the entire number collected are distributed by the wind?

17. What per cent of the entire number are provided with sails or wings?

18. What per cent of the fruits collected are not provided with any appendages which aid directly in their distribution?

19. What per cent of the entire collection are thrown from the pod when ripe?

20. The number that will roll on sloping ground is what per cent of the entire collection?

21. The number that will float on water is what per cent of the entire collection?

PHYSICS.

EBULLITION.

The following problems are to be used in showing how the boiling point is affected by the salts in solution and also, that the boiling point varies with the nature of the liquid. The experiments may be varied by using distilled water, hydrant water, spring water, and water containing different substances dissolved in varying amounts up to the point of saturation. The boiling point of pure water at the sea level with the barometer at thirty inches is 212° Fahrenheit.

PROBLEMS.

I. WHOLE NUMBERS.

1. What is the difference between the boiling point of pure distilled water and that of hydrant water? Hydrant water and well or spring water? Distilled water and spring water?

2. What is the difference, in degrees, between the boiling point of distilled water and the boiling point of alcohol?

3. In ninety cubic centimeters of distilled water, dissolve ten grams of salt; how much does this raise the boiling point?

4. In ninety cubic centimeters of distilled water,

dissolve ten grams of alum; how much does it raise the boiling point?

5. What is the difference between the boiling point of a saturated salt solution and the boiling point of pure water?

6. What is the difference between the boiling point of a saturated alum solution and the boiling point of pure water?

7. What is the difference between the boiling point at your elevation and the boiling point at sea level?

II. FRACTIONS.

1. The boiling point, in degrees, of pure water equals what part of the boiling point of hydrant water? Spring water? Well water?

2. The boiling point, in degrees, of alcohol equals what part of the boiling point of pure water?

3. The boiling point, in degrees, of pure water equals what part of the boiling point of ninety cubic centimeters of water in which ten grams of salt are dissolved? Twenty grams of salt?

4. The boiling point, in degrees, of pure water equals what part of that of ninety cubic centimeters of water in which ten grams of alum have been dissolved? Twenty grams?

5. The boiling point, in degrees, of pure water equals what part of the boiling point of a saturated salt solution?

6. The boiling point, in degrees, of pure water equals what part of the boiling point of a saturated alum solution?

7. The boiling point, in degrees, at your elevation

equals what part of the boiling point at sea level?

III. RATIO.

1. What is the ratio of the boiling point of pure water, expressed in degrees, to the boiling point of hydrant water? To that of spring water?

2. What is the ratio of the boiling point of pure water, expressed in degrees, at your altitude to the boiling point at the sea level?

3. What is the ratio of the boiling point, expressed in degrees, of alcohol to the boiling point of pure water?

4. What is the ratio of the boiling point of pure water, expressed in degrees, to the boiling point of ninety cubic centimeters of distilled water with ten grams of salt dissolved in it?

5. What is the ratio of the boiling point of pure water, expressed in degrees, to that of ninety cubic centimeters of distilled water, with ten grams of alum dissolved in it?

6. What is the ratio of the boiling point of distilled water, expressed in degrees, to the boiling point of a saturated salt solution?

7. What is the ratio of the boiling point of distilled water, expressed in degrees, to the boiling point of a saturated alum solution?

IV. PERCENTAGE.

1. The boiling point of distilled water, expressed in degrees, equals what per cent of the boiling point of hydrant water? Spring water? Well water?

2. The boiling point of pure water, expressed in degrees, at your altitude equals what per cent of the boiling point at sea level?

3. The boiling point of alcohol, expressed in degrees, equals what per cent of the boiling point of pure water?

4. The boiling point of pure water, expressed in degrees, equals what per cent of the boiling point of a ten per cent salt solution?

5. The boiling point of distilled water, expressed in degrees, equals what per cent of the boiling point of a ten per cent alum solution?

6. The boiling point of pure water, expressed in degrees, equals what per cent of the boiling point of a saturated salt solution?

7. The boiling point of pure water, expressed in degrees, equals what per cent of the boiling point of a saturated alum solution?

METEOROLOGY.

I. WHOLE NUMBERS.

A. Temperature.

1. What is the average reading of the thermometer for October?

2. What was the greatest range in the reading of the thermometer during the month?

3. What was the average reading of the thermometer for the first week? Second week? Third week? Fourth week?

4. What is the greatest difference between the average reading of the thermometer for any two weeks?

5. What is the difference between the lowest reading of the thermometer in October and the lowest reading in September?

6. What is the difference between the highest reading of the thermometer in October and the highest reading in September?

7. What is the difference betweeu the average reading of the thermometer in October and the average reading for September?

8. What is the difference, in degrees, between the greatest range of temperature in October and the greatest range in September?

B. Barometer.

9. What is the difference between the highest and the lowest barometric reading for October?

10. What is the average hight of the barometric column for October?

11. What is the average hight of the barometric column for the first week? The second week? The third week? The fourth week?

12. What is the difference between the average hight of the barometric column for October and the average hight for September?

13. What is the difference between the greatest barometric range for October and the greatest range for September?

C. Rainy, Cloudy, and Clear Days.

14. How many rainy days in October? How many days without rain? At the same rate how many of each would there be in a year?

15. Which month had the greater number of rainy days, and how much, October or September?

16. Which month had the greater number of days without rain, and how much, October or September?

D. Rainfall.

17. What was the total rainfall for October?

18. What was the average rainfall for each rainy day in October?

19. What was the average daily rainfall for the month?

20. At the October rate, what would be the total rainfall for a year?

21. Which had the greater rainfall, and how much, October or September?

22. What was the average rainfall for the two months?

23. What was the average rainfall for each rainy day during the two months?

24. What was the daily average rainfall for the two months?

25. Which was greater, and how much, the number of clear days, or the number of cloudy days in October?

26. What was the daily average of rainfall for each cloudy day in October?

27. Which was the greater, and how much, the average rainfall for the cloudy days of October or for the cloudy days of September?

28. At the October rate, how many days of the year would be cloudy?

E. Dew, Frost, and Fogs.

29. How many dewy mornings in October?

30. How many mornings with frost?

31. Which month had the greater number of dews, and how much, October or September? The greater number of frosts?

II. FRACTIONS.

A. Temperature.

1. The average reading of the thermometer for the month equals what part of the highest reading for the month? Of the lowest?

2. The average reading of the thermometer for the month equals what part of the average reading

for the first week? The second week? The third week? The fourth week?

3. The average reading of the thermometer for October is what part of the average reading for September?

4. The highest reading of the thermometer for October equals what part of the highest reading for September?

5. The lowest reading of the thermometer for October equals what part of the lowest reading for September?

6. The greatest range in degrees of the temperature in October equals what part of the greatest range in September?

B. Barometer.

7. The average hight of the barometer for October equals what part of the highest barometer? Of the lowest?

8. The average hight of the barometer for October equals what part of the average hight for September?

9. The greatest range in the barometric reading for October equals what part of the greatest range for September?

10. The average hight of the barometer for the rainy days during the month equals what part of the average hight for the clear days?

11. The average hight of the barometer for the rainy days equals what part of the average hight for the cloudy days without rain?

12. The average hight of the barometer for the rainy days in October equals what part of the average hight for the rainy days in September?

13. The average hight of the barometer for the clear days in October equals what part of the average hight for the clear days in September?

C. Rainy, Cloudy, and Clear Days.

14. The number of rainy days for October equals what part of the entire month? The cloudy days equal what part of the month?

15. The number of rainy days equals what part of the number of cloudy days in October?

16. The number of rainy days equals what part of the number of clear days in October?

17. The number of rainy days for October equals what part of the number of rainy days for September?

18. The number of cloudy days in October equals what part of the number of cloudy days in September?

19. The number of cloudy days without rain in October equals what part of the number of cloudy days without rain in September?

20. The number of clear days in October equals what part of the number of clear days in September?

21. At the October and September rate what part of the entire year would be rainy? What part of the year would be cloudy?

D. Rainfall.

22. The rainfall for October equals what part of the rainfall for September?

23. The average rainfall for each rainy day in October equals what part of the average for the rainy days in September?

24. The average rainfall for the cloudy days in October equals what part of the average for the cloudy days in September?

25. What part of the total rainfall occurred when the barometer was below the average hight for the month?

26. What part of the total rainfall occurred when the wind was blowing in the prevailing direction?

27. What part of the rainfall occurred when the temperature was below the monthly average?

E. Dew and Frost.

28. The number of mornings with dew equals what part of the entire month?

29. The number of mornings with frost equals what part of the entire month?

30. The number of mornings with frost in October equals what part of the number in September?

III. RATIO.

A. Temperature.

1. What is the ratio of the lowest reading of the thermometer to the highest reading in October?

2. What is the ratio of the average reading of the thermometer for the first week to the monthly average?

3. What is the ratio of the average reading of the thermometer for the second week to the average reading for the month? Of the third week? Of the fourth week?

4. What is the ratio of the average reading of

the thermometer for the first week to the average reading for the last week of the month?

5. What is the ratio of the average reading of the thermometer for October to the average reading for September?

6. What is the ratio of the greatest range of temperature during October to the greatest range during September?

7. What is the ratio of the highest reading of the thermometer in October to the highest reading in September?

8. What is the ratio of the lowest reading of the thermometer in October to the lowest reading in September?

B. Barometer.

9. What is the ratio of the highest barometric reading to the lowest reading for October?

10. What is the ratio of the average barometric reading on the rainy days to the average reading on the clear days?

11. What is the ratio of the average barometric reading on the rainy days to the average reading on the cloudy days without rain?

12. What is the ratio of the average barometric reading for October to the average reading for September?

13. What is the ratio of the greatest range of the barometer in October to the greatest range in September.

14. What is the ratio of the average barometric reading during the rainy days in October to the average reading during the rainy days in September?

C. Rainy, Cloudy, and Clear Days.

15. What is the ratio of the number of rainy days to the number of cloudy days in October?

16. What is the ratio of the number of rainy days to the number of clear days in October?

17. What is the ratio of the number of rainy days in October to the number of cloudy days without rain?

18. What is the ratio of the number of cloudy days in October to the number of clear days?

19. What is the ratio of the number of rainy days in October to the number of rainy days in September?

20. What is the ratio of the number of cloudy days in October to the number of cloudy days in September?

21. What is the ratio of the number of cloudy days without rain in October to the number of cloudy days without rain in September?

22. What is the ratio of the number of clear days in October to the number of clear days in September?

D. Rainfall.

23. What is the ratio of the rainfall for the first week to the rainfall for the month? Of the second week? Of the third week? Of the fourth week?

24. What is the ratio of the daily average rainfall for the rainy days to the daily average for the entire month?

25. What is the ratio of the daily average rain-

fall for the rainy days to the daily average for the entire number of cloudy days in the month?

26. What is the ratio of the total rainfall in October to the total rainfall for September?

27. What is the ratio of the daily average rainfall for the rainy days in October to that for the rainy days in September?

28. What is the ratio of the daily average rainfall for the cloudy days in October to that for the cloudy days in September?

E. Dew and Frost.

29. What is the ratio of the number of dews to the number of frosts in October?

30. What is the ratio of the number of dews in October to the number in September?

31. What is the ratio of the number of frosts in October to the number in September?

IV. PERCENTAGE.

A. Temperature.

1. The lowest reading of the thermometer in October equals what per cent of the highest reading?

2. The average reading of the thermometer for the first week in October equals what per cent of the monthly average? For the second week? For the third week? For the fourth week?

3. The average reading of the thermometer for the first week equals what per cent of that for the last week?

4. The average reading of the thermometer for October equals what per cent of the average for September?

5. The highest reading of the thermometer for October equals what per cent of the highest reading for September?

6. The lowest reading of the thermometer for October equals what per cent of the lowest reading for September?

7. The greatest range of temperature for October equals what per cent of the greatest range for September?

B. Barometer.

8. The lowest barometer in October equals what per cent of the highest reading?

9. The average hight of the barometer for the rainy days equals what per cent of the average hight for the clear days?

10. The average hight of the barometer for the rainy days equals what per cent of the average hight for the cloudy days without rain?

11. The average hight of the barometer for October equals what per cent of the average hight for September?

12. The average hight of the barometer for the rainy days in October equals what per cent of the average hight for the rainy days in September?

13. The average hight of the barometer for the clear days in October equals what per cent of the average hight for September?

14. The highest barometric reading for October equals what per cent of the highest barometric reading for September?

C. Rainy, Cloudy, and Clear Days.

15. The number of rainy days equals what per cent of the whole month?

16. The number of cloudy days equals what per cent of the entire month? The number of clear days?

17. The number of rainy days equals what per cent of the number of cloudy days? Of the number of clear days?

18. The number of cloudy days without rain equals what per cent of the whole number of cloudy days? Of the entire month?

19. The number of rainy days in October equals what per cent of the number of rainy days in September?

20. The number of cloudy days in October equals what per cent of the number of cloudy days in September?

21. The number of cloudy days without rain in October equals what per cent of the number of cloudy days without rain in September?

22. The number of clear days in October equals what per cent of the number of clear days in September?

23. At the October and September rate what per cent of the entire year would be rainy?

D. Rainfall.

24. The rainfall for October equals what per cent of the rainfall for September?

25. The average rainfall for each rainy day in October equals what per cent of the average for each rainy day in September?

26. The average daily rainfall for the entire month of October equals what per cent of the average for September?

27. The average daily rainfall for the cloudy days in October equals what per cent of the average for the cloudy days in September?

28. What per cent of the rainfall occurred when the barometer was below the average hight?

29. What per cent of the rainfall occurred when the prevailing wind for the month was blowing?

E. Dew and Frost.

30. The number of mornings with dew equals what per cent of the entire month of October?

31. The number of mornings with frost equals what per cent of the entire month?

32. The frosty mornings in October equals what per cent of the dewy mornings in September?

ASTRONOMY.

VARIATION IN DAY'S LENGTH AND POSITION OF THE SUN ON THE MERIDIAN.

I. WHOLE NUMBERS.

1. What is the change in the day's length during the first week? During the second? During the third? During the fourth?

2. What was the total change in the day's length for the entire month?

3. How many minutes did the day's length vary in the morning during the first week? The second? The third? The fourth?

4. How many minutes did the day's length vary in the morning during the month?

5. How many minutes did the day's length vary in the evening during the first week? The second? The third? The fourth?

6. How many minutes did the day's length vary in the evening during the entire month?

7. Which is greater during the month, and how much, the variation in the morning or the variation in the evening?

8. Which is greater, and how much, the variation during the first week or the variation during the last week?

9. How many degrees did the sun change on

the meridian during the month? How many degrees each week?

10. What is the difference between the length of day and the length of night at the beginning of the month?

11. What is the difference between the length of day and the length of night at the end of the month?

12. What was the change, and how much, in the length of the day from the first of September till the last of October?

13. What is the difference between the change in day's length in September and the change in October?

14. What is the difference between the change in day's length in the first week in September and the change in the last week in October?

15. Which was greater, and how much, the movement of the sun on the meridian in September or its movement on the meridian in October?

16. What is the difference between the amount of the sun's movement on the meridian during the first week in September and the amount of its movement during the last week in October?

17. What is the difference between the area of the shadow cast by the shadow-stick during the first week in September and the area of the shadow cast during the first week of October?

18. What is the difference between the area of the shadow cast during the first week in October and the area of the shadow cast during the second week? The third week? The fourth week?

19. What is the difference between the area of the shadow cast by the shadow-stick during the first week in September and the area of that cast during the last week in October?

II. FRACTIONS.

1. What part of the day's length at the beginning of the month was lost or gained during the first week? During the second? During the third? During the fourth?

2. What part of the day's length at the beginning of the month was lost or gained during the entire month?

3. What part of the loss or gain during the first week in the month occurred in the morning? The second week? The third week? The fourth week?

4. What part of the loss or gain during the first week occurred in the evening? The second week? The third week? The fourth week?

5. The loss or gain during the month in the morning equals what part of the loss or gain during the evening?

6. The loss or gain in the day's length during the first week in the month equals what part of the loss or gain during the last week?

7 The movement of the sun on the meridian during the first week in the month equals what part of the movement for the entire month? The second week? The third week? The fourth week?

8. The gain or loss in the day's length during October equals what part of the gain or loss during September?

9. The gain or loss in the day's length during the last week in October equals what part of that during the first week in September?

10. The gain or loss in the day's length in the morning during October equals what part of the gain or loss for the same time during September?

11. The gain or loss in the day's length in the evening during October equals what part of the gain or loss for the same time during September?

12. The morning variation in the day's length during the last week in October equals what part of the morning variation the first week in September?

13. The evening variation in the day's length during the last week in October equals what part of the evening variation during the first week in September?

14. The change of the sun's position on the meridian during October equals what part of the change during September?

15. The change of the sun's position on the meridian during October equals what part of the entire change since September first?

16. The area of the shadow cast by the shadow-stick the first week in October equals what part of the area cast the last week?

17. The area of the shadow cast the first week in October equals what part of the area of the cross section of the stick?

18. The area of the shadow cast the first week in September equals what part of the area of that cast the last week in October?

III. RATIO.

1. What is the ratio of the variation in the day's length during the first week in October to that for the entire month? During the second? During the third? During the fourth?

2. What is the ratio of the day's length at the beginning of the month to the length at the end of the month?

3. What is the ratio of the morning variation in the day's length during the first week to the morning variation for the entire month? During the second week? During the third week? During the fourth week?

4. What is the ratio of the evening variation in the day's length during the first week to the evening variation for the entire month? During the second week? During the third week? During the fourth week?

5. What is the ratio of the morning variation in the day's length during the first week to the evening variation for the same time? During the second week? During the third week? During the fourth week?

6. What is the ratio of the morning variation in the day's length during the month to the evening variation for the same time?

7. The number of degrees through which the sun moves on the meridian during the first week bears what ratio to the entire number of degrees for the month? During the second week? During the third week? During the fourth week?

8. What is the ratio of the variation in the day's

length during October to the variation during September?

9. What is the ratio of the variation in the day's length during the last week in October to the variation during the first week in September?

10. What is the ratio of the morning variation in the day's length during October to the morning variation for September?

11. What is the ratio of the evening variation in the day's length during October to the evening variation during September?

12. What is the ratio of the morning variation during the last week in October to the morning variation during the first week in September?

13. What is the ratio of the evening variation in the day's length during October to the evening variation in September?

14. What is the ratio of the evening variation in the day's length during the last week of October to the evening variation during the first week in September?

15. What is the ratio of the number of degrees through which the sun moved on the meridian during October to the number of degrees passed through during September?

16. What is the ratio of the number of degrees through which the sun passed on the meridian during October to the entire number of degrees passed through in October and September?

17. The area of the cross section of the shadow-stick bears what ratio to the area of the shadow cast the first week in October?

18. The area of the shadow cast the first week in October bears what ratio to the area cast the second week? The third? The fourth?

19. The area of the shadow cast the first week in September bears what ratio to the area of the shadow cast the first week in October?

20. The area of the shadow cast the first week in September bears what ratio to the area of the shadow cast the last week in October?

IV. PERCENTAGE.

1. What per cent of the day's length was lost or gained during the first week in October? During the second? During the third? During the fourth?

2. What per cent of the day's length at the first of the month was gained or lost during the entire month?

3. What per cent of the gain or loss in the day's length during the first week occurred in the morning? During the second? During the third? During the fourth?

4. What per cent of the gain or loss in the day's length during the first week occurred in the evening? During the second? During the third? During the fourth?

5. The gain or loss in the day's length during the month in the morning equals what per cent of the gain or loss during the evening?

6. The gain or loss in the day's length during the first week equals what per cent of the gain or loss during the last week?

7. The movement of the sun on the meridian

during the first week equals what per cent of the movement on the meridian for the month? During the second week? During the third week? During the fourth week?

8. The gain or loss in the day's length during October equals what per cent of the gain or loss during September?

9. The gain or loss in the day's length during the last week in October equals what per cent of the gain or loss during the first week in September?

10. The gain or loss in the day's length in the morning during October equals what per cent of the gain or loss in the morning during September?

11. The gain or loss in the day's length in the evening during October equals what per cent of the gain or loss during the evening in September?

12. The morning variation in the day's length during the last week in October equals what per cent of the morning variation during the first week in September?

13. The evening variation in the day's length during the last week in October equals what per cent of the evening variation during the first week in September?

14. The number of degrees on the meridian through which the sun passed during October equals what per cent of the number passed through in September?

15. The number of degrees on the meridian through which the sun passed during the last week in October equals what per cent of the number passed through during the first week in September?

16. The number of degrees on the meridian through which the sun passed during October equals what per cent of the number of degrees passed through during the two months?

17. The area of the cross section of the shadow-stick equals what per cent of the area of the shadow measured the first week in October? The second? The third? The fourth?

18. The area of the shadow cast the first week in October equals what per cent of the area of the shadow cast the second week? The third? The fourth?

19. The area of the shadow cast the first week in September equals what per cent of the area of the shadow cast the first week in October?

20. The area of the shadow cast the first week in September equals what per cent of the area of the shadow cast the last week in October?

GEOGRAPHY.

NORTH AMERICA—DRAINAGE.

In the following lessons it is designed to give the pupils definite ideas respecting certain physical features of North America through a study of its great continental units, the river basins. This is an essential preliminary to an intelligent comprehension of the work which will be taken up later, referring to the various productions, and also to the commercial relations of different parts of the country.

I. WHOLE NUMBERS.

A. River Basins.

1. The area of the Mississippi basin is how much less than the area of the entire continent?

2. What is the difference in area between the Mississippi basin and the land drained by the rivers of the Atlantic slope?

3. What difference in area between the Mississippi basin and the basin of the St. Lawrence?

4. What difference in area between the Mississippi basin and the basin of the Hudson Bay system?

5. What is the difference in area between the Mississippi basin and the basin of the Mackenzie?

6. What is the difference in area between the Mississippi basin and the basin of the Yukon?

7. What is the difference in area between the Ohio basin and the basin of the Missouri?

8. What is the difference in area between the Ohio basin and the slope drained by the Atlantic system?

9. What is the difference in area between the Ohio basin and the basin of the St. Lawrence?

10. What is the difference in area between the Ohio basin and the slope drained by the Gulf system?

11. What is the difference in area between the Ohio basin and the basin of the Mackenzie?

12. What is the difference in area between the Ohio basin and the basin of the Yukon?

13. What is the difference in area between the Ohio basin and the basin of the Arkansas?

14. What is the difference in area between the Ohio basin and the basin of the Columbia?

15. What is the difference in area between the Ohio basin and the basin of the Colorado?

16. What is the difference in area between the Missouri basin and the basin of the St. Lawrence?

17. What is the difference in area between the Missouri basin and the basin of the Hudson Bay system?

18. What is the difference in area between the Missouri basin and the slope drained by the Gulf system?

19. What is the difference in area between the Missouri basin and the basin of the Mackenzie?

20. What is the difference in area between the Missouri basin and the basin of the entire Mississippi system?

21. What is the difference in area between the St. Lawrence basin and the basin of the Hudson Bay system?

22. What is the difference between the area of the St. Lawrence basin and the slope drained by the Atlantic system?

B. Length of Rivers.

23. What is the difference in length between the Mississippi River and the Ohio River? The Missouri?

24. What is the difference in length between the Mississippi River and the St. Lawrence River?

25. What is the difference in length between the Mississippi River and the Mackenzie River?

26. What is the difference in length between the Mississippi River and the Columbia River?

27. What is the difference in length between the Mississippi River and the Yukon River?

28. What is the difference in length between the Missouri River and the Ohio River?

29. What is the difference in length between the Missouri River and the St. Lawrence River?

30. What is the difference in length between the Ohio River and the St. Lawrence River?

31. What is the difference in length between the Ohio River and the Arkansas River? The Red?

32. What is the difference in length between the Ohio River and the Colorado River? The Columbia?

II. FRACTIONS.

A. River Basins.

1. The area of the Mississippi basin equals what part of the area of the continent?

2. The area of the Mississippi basin equals what part of the area drained by the Atlantic system?

3. The area of the Mississippi basin equals what part of the area drained by the St. Lawrence system?

4. The area of the Mississippi basin equals what part of the area drained by the Hudson Bay system?

5. The area of the Mississippi basin equals what part of the area drained by the Mackenzie system?

6. The area of the Mississippi basin equals what part of the area drained by the Yukon system?

7. The area of the Mississippi basin equals what part of the area drained by the Columbia system? The Colorado?

8. The area of the St. Lawrence basin equals what part of the area drained by the Atlantic system?

9. The area of the St. Lawrence basin equals what part of the area drained by the Hudson Bay system?

10. The area of the St. Lawrence basin equals what part of the area drained by the Mackenzie system?

11. The area of the St. Lawrence basin equals what part of the area drained by the Gulf system?

12. The area of the Ohio basin equals what part of the area drained by the Mississippi system?

13. The area of the Ohio basin equals what part of the area drained by the Missouri system?

14. The area of the Ohio basin equals what part of the area drained by the Atlantic system?

15. The area of the Ohio basin equals what part of the area drained by the Gulf system?

16. The area of the Ohio basin equals what part of the area drained by the Columbia system? The Colorado? The Red? The Arkansas?

17. The area of the Missouri basin equals what part of the area drained by the entire Mississippi system?

18. The area of the Missouri basin equals what part of the area drained by the Atlantic system?

19. The area of the Missouri basin equals what part of the area drained by the Gulf system?

20. The area of the Missouri basin equals what part of the area drained by the Mackenzie system?

21. The area of the Missouri basin equals what part of the area drained by the Yukon system?

22. The area of the Missouri basin equals what part of the area drained by the Columbia system?

23. The area of the Missouri basin equals what part of the area drained by the Colorado system?

24. The area drained by the Gulf system equals what part of the area drained by the Atlantic system?

25. The area drained by the Atlantic system equals what part of the area drained by the Arctic system?

B. Length of Rivers.

26. The length of the Ohio River equals what part of the length of the Mississippi River.

27. The length of the Ohio River equals what part of the length of the Missouri River.

28. The length of the Ohio River equals what part of the length of the St. Lawrence River?

29. The length of the St. Lawrence River equals what part of the length of the Mississippi River?

30. The length of the St. Lawrence River equals what part of the length of the Missouri River?

31. The length of the St. Lawrence River equals what part of the length of the Mackenzie River.

32. The length of the St. Lawrence River equals what part of the length of the Yukon River?

33. The length of the Missouri River equals what part of the length of the Mackenzie River? Of the Yukon River?

34. The length of the Missouri River equals what part of the length of the Columbia River? The Colorado River?

III. RATIO.

A. River Basins.

1. What is the ratio of the area of the Mississippi basin to the area of the entire continent?

2. What is the ratio of the area drained by the Atlantic system to the area of the entire continent?

3. What is the ratio of the area drained by the Gulf system to the area of the entire continent?

4. What is the ratio of the area of the St. Lawrence basin to the area of the Mississippi basin?

5. What is the ratio of the area of the Atlantic slope to the area of the basin of the Mississippi River?

6. What is the ratio of the area drained by the Gulf system to the area of the Mississippi basin?

7. What is the ratio of the area of the Mackenzie basin to the area of the Mississippi basin?

8. What is the ratio of the area of the Yukon basin to the area of the Mississippi basin?

9. What is the ratio of the area of the Columbia basin to the area of the Mississippi basin?

10. What is the ratio of the area of the Colorado basin to the area of the Mississippi basin?

11. What is the ratio of the area of the Ohio basin to the area of the Mississippi basin?

12. What is the ratio of the area of the Missouri basin to the area of the Mississippi basin?

13. What is the ratio of the area of the Ohio basin to the area of the Missouri basin?

14. What is the ratio of the area of the Ohio basin to the area of the St. Lawrence basin.

15. What is the ratio of the area of the Ohio basin to the area drained by the Atlantic system?

16. What is the ratio of the area of the Ohio basin to the area drained by the Gulf system?

17. What is the ratio of the area of the Ohio basin to the area of the Mackenzie basin?

18. What is the ratio of the area of the Ohio basin to the area of the Yukon basin?

19. What is the ratio of the area of the Ohio basin to the area of the Columbia basin?

20. What is the ratio of the area of the Ohio basin to the area of the Colorado basin?

21. What is the ratio of the area of the Ohio basin to the area of the Arkansas basin?

22. What is the ratio of the area of the Ohio basin to the area of the Red River basin?

23. What is the ratio of the area of the St. Lawrence basin to the area of the Mackenzie basin?

24. What is the ratio of the area of the St. Lawrence basin to the area drained by the Atlantic system?

25. What is the ratio of the area of the St. Lawrence basin to the area of the Columbia basin? The Colorado basin?

B. Length of Rivers.

26. The length of the Ohio River bears what ratio to the length of the Mississippi River?

27. The length of the Ohio River bears what ratio to the length of the Missouri River?

28. The length of the Ohio River bears what ratio to the length of the St. Lawrence River?

29. The length of the Ohio bears what ratio to the length of the Columbia River? The Colorado River? The Arkansas River? The Red River?

30. The length of the St. Lawrence River bears what ratio to the length of the Mississippi River?

31. The length of the Mackenzie River bears what ratio to the length of the Mississippi River?

32. The length of the Yukon River bears what ratio to the length of the Mississippi River?

33. The length of the Columbia River bears what ratio to the length of the Colorado River? The Arkansas River? The Red River?

34. The length of navigable waters in the

Mississippi system bears what ratio to the total length of the rivers in this system?

IV. PERCENTAGE.

A. River Basins.

1. The area of the Mississippi basin equals what per cent of the area of the continent?

2. The area drained by the Atlantic system equals what per cent of the area of the continent?

3. The area drained by the Gulf system equals what per cent of the area of the continent?

4. The area of the Ohio basin equals what per cent of the area of the Mississippi basin?

5. The area of the Missouri basin equals what per cent of the area of the Mississippi basin?

6. The area of the Arkansas basin equals what per cent of the area of the Mississippi basin?

7. The area of the Red River basin equals what per cent of the area of the Mississippi basin?

8. The area of the St. Lawrence basin equals what per cent of the area of the Mississippi basin?

9. The area drained by the Atlantic system equals what per cent of the area of the Mississippi basin?

10. The area drained by the Gulf system equals what per cent of the area of the Mississippi basin?

11. The area of the Mackenzie basin equals what per cent of the area of the Mississippi basin?

12. The area of the Yukon basin equals what per cent of the area of the Mississippi basin?

13. The area of the Columbia basin equals what per cent of the area of the Mississippi basin?

14. The area of the Colorado basin equals what per cent of the area of the Mississippi basin?

15. The area of the Ohio basin equals what per cent of the area of the St. Lawrence basin?

16. The area of the Ohio basin equals what per cent of the area drained by the Atlantic system?

17. The area of the Ohio basin equals what per cent of the area drained by the Gulf system?

18. The area of the Ohio basin equals what per cent of the area of the Missouri basin?

19. The area of the Ohio basin equals what per cent of the area of the Columbia basin?

20. The area of the Ohio basin equals what per cent of the area of the Colorado basin?

21. The area of the Ohio basin equals what per cent of the area of the Arkansas basin? The Red River basin?

22. The area of the Missouri basin equals what per cent of the area of the St. Lawrence basin?

23. The area of the Missouri basin equals what per cent of the area drained by the Atlantic system.

24. The area of the Missouri basin equals what per cent of the area of the Mackenzie basin?

25. The area of the Missouri basin equals what per cent of the area of the Columbia basin? The Colorado basin?

B. Length of Rivers.

26. The length of the Ohio River equals what per cent of the length of the Mississippi River?

27. The length of the Missouri River equals what per cent of the length of the Mississippi River?

28. The length of the Arkansas equals what per cent of the length of the Mississippi River?

29. The length of the Red River equals what per cent of the length of the Mississippi River?

30. The length of the St. Lawrence River equals what per cent of the length of the Mississippi River?

31. The length of the Mackenzie River equals what per cent of the length of the Mississippi River?

32. The length of the Yukon River equals what per cent of the length of the Mississippi River?

33. The length of the Columbia River equals what per cent of the length of the Mississippi River?

34. The length of the Colorado River equals what per cent of the length of the Mississippi River?

35. The length of the Ohio River equals what per cent of the length of the St. Lawrence River?

36. The length of the Ohio River equals what per cent of the length of the Missouri River?

37. The length of the Ohio River equals what per cent of the length of the Columbia River?

38. The length of the Ohio River equals what per cent of the length of the Colorado River?

39. The length of the Missouri River equals what per cent of the length of the St. Lawrence River?

40. The length of the Missouri River equals what per cent of the length of the Mackenzie River?

MINERALOGY.

PHYSICAL PROPERTIES OF MINERALS.

The following problems may be used in different ways, varying with the method of study pursued. They may be used in reviewing the work previously done, or they may be used after a field lesson in giving the pupils a more definite idea of the proportions in which the different minerals are to be found in the neighborhood. The class may be required to group their entire collection with respect to luster, for example, and then note the number in each group and the comparative size of the different groups. In this way, the physical properties may be taught or reviewed and a knowledge of the relative numbers may be gained at the same time.

PROBLEMS.

I. WHOLE NUMBERS.

1. How many minerals have you in your entire collection?

2. How many minerals have you with metallic luster?

3. How many minerals have you with non-metallic luster?

4. How many minerals have you with glassy or vitreous luster? Pearly luster? Resinous luster?

Pitchy luster? Silky luster? Greasy or waxy luster? Dull luster?

5. How many minerals have you that are transparent? Opaque? Translucent? Semi-transparent? Sub-translucent?

6. How many minerals have you that are *very hard, i. e.*, scratch glass or quartz?

7. How many minerals have you that are *hard, i. e.*, not easily scratched by a knife—scratch glass.

8. How many minerals have you that are *soft, i. e.*, can not be scratched with finger nail—easily scratched with a knife?

9. How many minerals have you that are *very soft, i. e.*, can be scratched with the finger nail or very easily with a knife?

10. How many of your minerals are brittle? Malleable? Sectile? Flexible? Elastic?

11. How many of your minerals dissolve in acid? How many are insoluble in acid?

12. How many of your minerals are fusible? How many are infusible?

13. How many of your minerals have a white streak? Black streak? Brown streak? Red streak? Yellow streak?

14. How many minerals have you whose streak is the same color as that of the mineral? How many different?

15. How many minerals have you that are crystalline? How many are not so?

16. Which is greater, and how much, the number with metallic, or the number with non-metallic luster?

17. Which is greater, and how much, the number of transparent, or the number of opaque minerals?

18. Which is greater, and how much, the number of transparent, or the number of translucent minerals?

19. Which is greater, and how much, the number of minerals that are *very hard*, or the number that are *very soft?*

20. Which is greater, and how much, the number of minerals soluble in acid, or the number insoluble?

21. Which is greater, and how much, the number of minerals fusible or the number infusible?

22. Which is greater, and how much, the number of crystalline, or the number of non-crystalline minerals?

II. FRACTIONS.

1. What part of your collection has metallic luster? Non-metallic?

2. What part of your collection has vitreous luster? Pearly? Resinous? Pitchy? Silky? Waxy or greasy? Dull?

3. What part of your collection is transparent? Translucent? Semi-transparent? Sub-translucent? Opaque?

4. What part of your collection is *very hard*, *i. e.*, will scratch glass or quartz?

5. What part of your collection is *hard*, *i. e.*, not easily scratched by a knife—will scratch glass?

6. What part of your collection is *soft*, *i. e.*, can

not be scratched with the finger nail — easily scratched by a knife?

7. What part of your collection is *very soft, i. e.*, can be scratched by finger nail — very easily scratched by a knife?

8. What part of your collection is brittle? Malleable? Sectile? Flexible? Elastic?

9. What part of your collection is soluble in acid? What part is insoluble?

10. What part of your collection is fusible?

11. What part of your collection is infusible?

12. What part of your collection has a white streak? Black streak? Brown streak? Red streak? Yellow streak?

13. What part of your minerals has streak and color alike? What part unlike?

14. What part of your collection is crystalline? What part is not so?

15. What part of your minerals is foliated? Stratified? Amorphous?

16. The minerals with metallic luster equal what part of the number non-metallic?

17. The minerals that are transparent equal what part of the number that are opaque?

18. The number of minerals that are *very hard* equals what part of the number that are *very soft?*

19. The number of minerals that are soluble in acid equals what part of the number that are insoluble?

20. The number of minerals that are fusible equals what part of the number that are infusible?

21. The number of amorphous forms equals what part of the number of crystalline forms?

III. RATIO.

1. What is the ratio of the number of minerals with metallic luster to the number in the entire collection? Of the non-metallic?

2. What is the ratio of the number of minerals with vitreous luster to the number in your entire collection? Of the number with pearly luster? Of the number with resinous luster? Of the number with pitchy luster? Of the number with silky luster? Of the number with waxy luster? Of the number with dull luster?

3. What is the ratio of the number of minerals that are transparent to the number in your entire collection? Of the number that are semi-transparent? Of the number that are translucent? Of the number that are sub-translucent? Of the number that are opaque?

4. What is the ratio of the number of minerals that are *very hard* (see previous lessons) to the number in your entire collection? Of the number that are *hard?* Of the number that are *soft?* Of the number that are *very soft?*

5. What is the ratio of the number of minerals in your collection that are brittle to your entire number? Of the number that are malleable? Of the number that are sectile? Of the number that are flexible? Of the number that are elastic?

6. What is the ratio of the number of minerals that are soluble in acid to the number in your entire collection? Of the number that are insoluble?

7. What is the ratio of the number of minerals that are fusible to the number in your entire collection? Of the number that are infusible?

8. What is the ratio of the number of minerals with a white streak to the number in your entire collection? Of the number with black streak? Of the number with brown streak? Of the number with red streak? Of the number with yellow streak?

9. What is the ratio of the number of minerals which have streak and color alike to the whole number in your entire collection? Of those with streak and color different?

10. What is the ratio of the number of crystalline forms in your collection to the whole number?

11. What is the ratio of the number of transparent minerals to the number of opaque minerals?

12. What is the ratio of the number of *very hard* minerals to the number of *very soft?*

13. What is the ratio of the number of minerals soluble in acid to the number insoluble?

14. What is the ratio of the number of minerals that are fusible to the number infusible?

15. What is the ratio of the number of crystalline minerals to the number non-crystalline?

IV. PERCENTAGE.

1. What per cent of your minerals have metallic luster?

2. What per cent of your minerals have non-metallic luster?

3. What per cent of your minerals have

vitreous luster? Pearly? Resinous? Pitchy? Silky? Waxy or greasy? Dull?

4. What per cent of your minerals are *very hard?* (See previous lessons for scale of hardness.)

5. What per cent of your minerals are *hard?*

6. What per cent of your minerals are *soft?*

7. What per cent of your minerals are *very soft?*

8. What per cent of your minerals are brittle? Malleable? Sectile? Flexible? Elastic?

9. What per cent of your minerals are soluble in acid?

10. What per cent of your minerals are insoluble in acid?

11. What per cent of your minerals are fusible?

12. What per cent of your minerals are infusible?

13. What per cent of your minerals have a white streak? Black streak? Brown streak? Red streak? Yellow streak?

14. What per cent of your minerals have color and streak alike?

15. What per cent of your minerals have color and streak different?

16. What per cent of your minerals are crystalline? Amorphous? Foliated? Fibrous?

17. The minerals with metallic luster equal what per cent of the minerals that are non-metallic?

18. The transparent minerals equal what per cent of the opaque minerals?

19. The transparent minerals equal what per cent of the translucent minerals?

20. The *very hard* minerals equal what per cent of the *very soft* minerals?

21. The minerals soluble in acid equal what per cent of the minerals that are insoluble?

22. The fusible minerals equal what per cent of the minerals that are infusible?

23. The amorphous forms equal what per cent of the minerals that are crystalline?

ZOÖLOGY.

WINTER HABITS OF ANIMALS.

The pupils should make a complete list of all the animals that inhabit the surrounding country during the whole or any part of the year. The present condition of these should be studied, and the groups given below are suggested for the purpose of giving more definite ideas concerning this interesting period of animal life. From the swift-winged bird at one extreme, through almost every possible intermediate gradation, to the reptile in a state of complete stupefaction at the other, one sees a plasticity of the animal organism that is truly remarkable; and, when it is remembered that the same laws of nutrition, assimilation, and excretion govern all, nothing more clearly than this study shows the extreme modifications which the animal functions and structure may undergo without destroying the organism itself. The animals with which the pupils are familiar may be grouped as follows:

1. Animals that migrate on the approach of winter.
2. Animals that remain and feed abroad during the winter.
3. Animals that store food for winter use.
4. Animals that hibernate without food.

5. Animals that die on the approach of winter.

6. Animals that appear in the neighborhood during winter only.

PROBLEMS.

I. WHOLE NUMBERS.

1. How many different kinds of animals migrate in autumn?

2. How many different kinds of animals remain abroad to feed during the winter?

3. How many different kinds of animals store food for winter use?

4. How many different kinds of animals hibernate without food?

5. How many different kinds of animals die on the approach of winter?

6. How many different kinds of animals appear only in winter?

7. How many different kinds of animals remain in the neighborhood, in one condition or another, during the entire winter?

8. Which is greater, and how much, the number of animals migrating or the number staying?

9. Which is greater, and how much, the number of different kinds of animals that store food for winter or the number that hibernate without it?

10. Which is greater, and how much, the number of different kinds of animals that die, or the number that live through the winter?

11. Which is greater, and how much, the number of different kinds of animals that hibernate without food or the number which feed abroad during winter?

12. Which is greater, and how much, the number of different kinds of animals which appear only in winter or the number which migrate?

II. FRACTIONS.

1. The number of different kinds of animals that migrate equals what part of all the different kinds of animals in the neighborhood?

2. The number of different kinds of animals that remain and feed abroad during the winter equals what part of the whole number belonging to the region?

3. The number of different kinds of animals that store food equals what part of the whole number of different kinds?

4. The number of different kinds of animals that hibernate without food equals what part of the whole number?

5. The number of different kinds of animals that die on the approach of winter equals what part of the whole number?

6. The number of different kinds of animals that appear only during winter equals what part of the whole number?

7. The number of different kinds of animals migrating equals what part of the number of different kinds which remain abroad?

8. The number of different kinds of animals storing food equals what part of the number of different kinds which feed abroad? Of those which migrate?

9. The number of different kinds of animals

hibernating equals what part of the number of different kinds which store food?

10. The number of different kinds of animals hibernating equals what part of the number of different kinds which feed abroad?

11. The number of different kinds of animals that die on the approach of winter equals what part of the number of different kinds which hibernate?

12. The number of different kinds of animals that die on the approach of winter equals what part of the number of different kinds which store food?

13. The number of different kinds of animals that die on the approach of winter equals what part of the number of different kinds which feed abroad?

14. The number of different kinds of animals that appear only in winter equals what part of the number of different kinds that migrate?

III. RATIO.

1. What is the ratio of the number of different kinds of animals that migrate to the entire number of different kinds in the region?

2. What is the ratio of the number of different kinds of animals that feed abroad to the entire number of different kinds belonging to the region?

3. What is the ratio of the number of different kinds of animals that store food to the entire number of different kinds belonging to the region?

4. What is the ratio of the number of different kinds of animals that hibernate to the entire number belonging to the region?

5. What is the ratio of the number of different kinds of animals that die on the approach of winter to the entire number of different kinds belonging to the region?

6. What is the ratio of the number of different kinds of animals that appear only during the winter to the entire number of different kinds belonging to the region?

7. What is the ratio of the number of different kinds of animals that feed abroad during the winter to the number of different kinds that migrate?

8. What is the ratio of the number of different kinds of animals that feed abroad during the winter to the number of different kinds that store food?

9. What is the ratio of the number of different kinds of animals that feed abroad during the winter to the number of different kinds that hibernate?

10. What is the ratio of the number of different kinds of animals that feed abroad during the winter to the number of different kinds that die on the approach of winter?

11. What is the ratio of the number of different kinds of animals that store food to the number of different kinds that hibernate?

12. What is the ratio of the number of different kinds of animals that store food to the number of different kinds that die on the approach of winter?

13. What is the ratio of the number of different kinds of animals that hibernate to the number of different kinds that die on the approach of winter?

14. What is the ratio of the number of different kinds of animals that hibernate to the number of different kinds that appear only in winter?

IV. PERCENTAGE.

1. What per cent of the different kinds of animals that belong to the region migrate?

2. What per cent of the different kinds of animals that belong to the region feed abroad during the winter?

3. What per cent of the different kinds of animals that belong to the region store food for the winter?

4. What per cent of the different kinds of animals that belong to the region hibernate without food?

5. What per cent of the different kinds of animals that belong to the region die on the approach of winter?

6. What per cent of the different kinds of animals that belong to the region appear only during winter?

7. The different kinds of animals that migrate equal what per cent of the different kinds that feed abroad during the winter?

8. The different kinds of animals that migrate equal what per cent of the different kinds that store food for winter?

9 The different kinds of animals that migrate equal what per cent of the different kinds that hibernate?

10. The different kinds of animals that migrate

equal what per cent of the different kinds that die on the approach of winter?

11. The different kinds of animals that feed abroad during the winter equal what per cent of the different kinds that store food for the winter?

12. The different kinds of animals that feed abroad during the winter equal what per cent of the different kinds that hibernate?

13. The different kinds of animals that feed abroad during the winter equal what per cent of the different kinds that die on approach of winter?

14. The different kinds of animals that store food for winter equal what per cent of the different kinds that hibernate?

15. The different kinds of animals that store food for winter equal what per cent of the different kinds that die on approach of winter?

16. The different kinds of animals that hibernate without food equal what per cent of the different kinds that die on approach of winter?

17. The different kinds of animals that die on the approach of winter equal what per cent of the different kinds that appear only during the winter?

BOTANY.

ANNUALS, BIENNIALS, AND PERENNIALS.

The lessons under this head are designed to give the pupils somewhat definite ideas of how plants prepare themselves for the winter season. Comparatively few plants carry their leaves through this season; a larger number have their hopes for the future stored up in a multitude of buds; others depend upon materials stored in roots or stems, while a great host depends upon the seeds only. The following classes may, therefore, be considered:

1. Those with leaves the year round—evergreens —perennials.

2. Those growing from year to year—the living material being found during the winter chiefly in buds—perennials.

3. Those preparing a root or stalk for the second season only—biennials.

4. Those dying, root and branch, the seed only being preserved—annuals.

PROBLEMS.

I. WHOLE NUMBERS.

1. How many different kinds of trees or plants can you find that bear leaves the year round?

2. How many different kinds of plants live through the winter but lose their leaves?

3. How many different kinds of plants can you find that die down to the root in the fall—the latter being preserved alive during the winter?

4. How many different kinds of plants can you find that die, root and stem, at the approach of winter?

5. Which is the larger, and how much, the number of different kinds of plants that live through the winter or the number of different kinds that die in autumn?

6. How many different kinds of plants can you find that produce both seeds and buds?

7. How many different kinds of plants can you find that begin winter without having formed seeds?

8. How many different kinds of perennials can you find?

9. How many different kinds of biennials can you find?

10. How many different kinds of annuals can you find?

11. Which is larger, and how much, the number of different kinds of perennials or the number of different kinds of biennials?

12. Which is larger, and how much, the number of different kinds of perennials or the number of different kinds of annuals?

II. FRACTIONS.

1. What part of all the different kinds of plants that you can find bears leaves the year round?

2. What part of the entire number of different kinds of plants observed loses its leaves in autumn?

3. What part of the entire number of different kinds of plants dies down to the root in autumn?

4. What part of the entire number of different kinds of plants dies, root and stem, in autumn?

5. What part of the entire number of different kinds of plants lives through the winter?

6. What part of the entire number of different kinds of plants produces both seeds and buds?

7. What part of the entire number of different kinds of plants begins winter without having formed seeds?

8. The perennials equal what part of all the different kinds of plants you can find?

9. The biennials equal what part of the entire number of different kinds of plants that you can find?

10. The annuals equal what part of the whole number of different kinds of plants that you can find?

11. The number of biennials equals what part of the number of perennials?

12. The number of annuals equals what part of the number of perennials?

III. RATIO.

1. The number of different kinds of plants that bear leaves the year round bears what ratio to the entire number of different kinds that you can find?

2. What is the ratio of the different kinds of plants that lose their leaves in autumn to the entire number of different kinds?

3. What is the ratio of the different kinds of plants that die down to the root in autumn to the entire number of different kinds?

4. What is the ratio of the different kinds of plants that die, root and branch, in autumn to the entire number of different kinds?

5. What is the ratio of the number of different kinds of plants that live through the winter to the whole number of different kinds?

6. What is the ratio of the number of different kinds of plants that produce both seeds and buds to the entire number of different kinds?

7. What is the ratio of the different kinds of plants that begin winter without having matured seeds to the entire number of different kinds?

8. What is the ratio of the evergreens to the entire number of perennials?

9. What is the ratio of the perennials to the whole number of different kinds of plants?

10. What is the ratio of the biennials to the whole number of different kinds of plants?

11. What is the ratio of the annuals to the whole number of different kinds of plants?

12. What is the ratio of the annuals to the perennials?

13. What is the ratio of the annuals to the biennials?

14. What is the ratio of the biennials to the perennials?

IV. PERCENTAGE.

1. What per cent of all the different kinds of plants that you can find bear leaves the year round?

2. What per cent of the different kinds of plants that you have observed lose their leaves in autumn?

3. The different kinds of plants that die down to the root in autumn are what per cent of the whole number of different kinds?

4. The different kinds of plants that die, root and stem, in autumn, are what per cent of the whole number of different kinds?

5. The different kinds of plants that live through the winter are what per cent of the whole number of different kinds?

6. The different kinds of plants that produce both seeds and buds are what per cent of the whole number of different kinds?

7. The different kinds of plants that begin winter without having formed seeds are what per cent of the whole number of different kinds?

8. The evergreens are what per cent of the perennials?

9. The perennials are what per cent of the entire number of different kinds of plants?

10. The biennials are what per cent of the entire number of different kinds of plants?

11. The annuals are what per cent of the entire number of different kinds of plants?

12. The annuals equal what per cent of the perennials?

13. The biennials equal what per cent of the perennials?

14. The biennials equal what per cent of the annuals?

PHYSICS.

HEAT—EXPANSION OF METALS.

It is not easy to devise apparatus, simple enough for use in the public schools, which will be worth much in obtaining quantitative results in this study of heat. Something, however, may be done with the following in showing the linear expansion of metal wires or rods. Construct a light wooden frame having a bottom piece about thirty centimeters long by eight in width, with an upright piece at each end of the same width and about fifteen centimeters high. Place one upright, which we will designate A, with its greatest width *across* the end of the bottom strip, and the other, designated B, on the opposite end of the bottom, but with its greatest width *lengthwise* with it. Near the top of A, and in the face next to B, bore a hole partly through large enough to receive the rod to be tested. At the same hight in B, and in one of the broad faces, insert a small screw-eye. One end of the rod rests against the back of the hole in A and the other passes through the screw-eye in B. To the face of B, and in contact with the end of the rod, attach a piece of steel spring (a worn-out watch-spring straightened will do) and allow it to reach down nearly to the bottom of the upright. Behind the lower end of the spring

on the face of B tack a small arc of a circle upon which degrees have been marked. Note the degree mark at which the spring stands when the cold rod is in place and in contact with it. Place a lamp under the middle of the rod and shield the flame to keep it steady. Note the exact time that the flame is applied and the number of spaces passed over by the index. Lay the rod aside, and while it is cooling try a similar rod of different material, and so on till all have been used. When the first rod is cool try it again in the same way, and continue thus with all the rest until an average result of at least five trials have been taken. Iron, brass, and copper rods may be easily obtained, and their relative linear expansibility may thus be approximately determined.

PROBLEMS.

I. WHOLE NUMBERS.

1. What was the average number of spaces over which the heated iron rod moved the index?

2. What was the average number of spaces over which the heated copper rod moved the index?

3. What was the average number of spaces over which the heated brass rod moved the index?

4. Which rod moved the index over the greater number of spaces, and how much, the iron or the copper?

5. Which rod moved the index over the greater number of spaces, and how much, the iron or the brass?

6. Which rod moved the index over the greater number of spaces, and how much, the copper or the brass?

7. Which rod moved the index over the greatest number of spaces?

8. Which rod moved the index over the least number of spaces?

II. FRACTIONS.

1. The average number of spaces over which the heated iron rod moved the index equals what part of the average number of spaces over which the copper rod moved it?

2. The average number of spaces over which the heated iron rod moved the index equals what part of the average number of spaces over which the brass rod moved it?

3. The average number of spaces over which the heated copper rod moved the index equals what part of the average number over which the brass rod moved it?

4. The least average expansibility shown by any one metal equals what part of that of the greatest average expansibility?

III. RATIO.

1. What is the ratio of the average number of spaces through which the heated iron rod moved the index to the average number through which the heated copper rod moved it?

2. What is the ratio of the average number of spaces through which the heated iron rod moved the index to the average number through which the heated brass rod moved it?

3. What is the ratio of the average number of spaces through which the heated copper rod moved

the index to the average number through which the heated brass rod moved it?

4. What is the ratio of the least degree of expansibility shown by any rod to the greatest degree shown by any rod?

IV. PERCENTAGE.

1. The average number of spaces through which the heated iron rod moved the index equals what per cent of the average number through which the copper rod moved it?

2. The average number of spaces through which the heated iron rod moved the index equals what per cent of the average number through which the brass rod moved it?

3. The average number of spaces through which the heated copper rod moved the index equals what per cent of the average number through which the brass rod moved it?

4. The least average expansibility shown by any of the rods equals what per cent of the greatest expansibility?

METEOROLOGY.

PROBLEMS.

I. WHOLE NUMBERS.

A. Temperature.

1. What is the difference between the average reading of the thermometer for November and the average reading for October? For September?

2. What is the difference between the average reading of the thermometer for November and the average reading for October *and* September?

3. What is the difference between the greatest range in temperature for this month and that for October? For September?

4. What is the difference between the lowest reading of the thermometer in November and the lowest reading in October? In September?

5. What is the difference between the highest reading of the thermometer in November and the highest reading for October? For September?

6. What is the average reading of the thermometer this month on the rainy days? On the clear days?

7. What is the average reading of the thermometer for the days on which the prevailing wind blew? How much was this average above or below the monthly average?

B. Barometer.

8. What is the difference between the average night of the barometer for November and the average hight for October? For September?

9. What is the difference between the greatest range in the barometer for November, and the greatest range for October? For September?

10. What is the difference between the average hight of the barometer for November and the average hight for October *and* September?

11. What is the difference between the average hight of the barometer for the rainy days in November and the average for the rainy days in October? For September?

12. What is the difference between the average hight of the barometer for the clear days in November and the average for the clear days in October? In September?

13. What is the difference between the average hight of the barometer for the clear days and the average for the cloudy days in November? Between the average for clear days and the average for the rainy days?

C. Rainy, Cloudy, and Clear Days.

14. What is the difference between the number of rainy days in November and the number in October? In September?

15. What is the difference between the number of cloudy days in November and the number in October? In September?

16. What is the difference between the number

of clear days in November and the number in October? In September?

17. What is the difference between the number of rainy days and the number of clear days in November? Rainy days and cloudy days? Cloudy days and clear days?

18. What is the difference between the number of cloudy days without rain in November and the number of cloudy days without rain in October? In September?

D. Rainfall.

19. Which had the greater rainfall, and how much, November or October? November or September?

20. Which had the greater rainfall, and how much, November or October *and* September?

21. At the November rate what would be the rainfall for a year?

22. What was the daily average rainfall for the month? Which is greater, and how much, the daily average rainfall for November, or the average for October? For November or September?

23. Which is greater, and how much, the daily average rainfall for the rainy days in November or the daily average for October? In November or September?

24. Which is greater, and how much, the daily average rainfall for the cloudy days in November or the daily average for October? For November or September?

E. Dew, Frost, Fogs.

25. Which is greater, and how much, the num-

ber of dews in November or the number in October? In November or September?

26. Which is greater, and how much, the number of frosts in November or the number in October? In November or September?

27. Which is greater, and how much, the number of foggy mornings in November or the number in October? In November or September?

28. How many more frosts than dews in November?

II. FRACTIONS.

A. Temperature.

1. The average reading of the thermometer for November equals what part of the average reading for October? For September?

2. The average reading of the thermometer for November equals what part of the average reading for October *and* September?

3. The greatest range of temperature in November equals what part of the greatest range for October? For September?

4. The lowest reading of the thermometer for November equals what part of the lowest reading for October? For September?

5. The highest reading of the thermometer for November equals what part of the highest for October? For September?

6. The average reading of the thermometer for the rainy days equals what part of the average reading for the clear days?

7. The average reading of the thermometer for the days on which the prevailing wind blew equals what part of the monthly average?

B. Barometer.

8. The average hight of the barometer for November equals what part of the average hight for October? For September?

9. The greatest range of barometer for November equals what part of the greatest range for October? For September?

10. The average barometer reading for November equals what part of the average for October *and* November?

11. The average hight of the barometer for the rainy days in November equals what part of that for the rainy days in October? In September?

12. The average hight of the barometer for the clear days in November equals what part of the average hight for the clear days in October? In September?

13. The average hight of the barometer for the rainy days in November equals what part of the average for the clear days?

14. The average hight of the barometer for the rainy days equals what part of the average hight for the cloudy days?

C. Rainy, Cloudy, and Clear Days.

15. The number of rainy days in November equals what part of the number of rainy days in October? In September?

16. The number of clear days in November equals what part of the number of clear days in October? In September?

17. The number of cloudy days in November

equals what part of the number of cloudy days in October? In September?

18. The number of cloudy days in November equals what part of the number of clear days?

19. The number of rainy days equals what part of the number of cloudy days in November?

20. The number of cloudy days without rain in November equals what part of the number without rain in October? In September?

21. At the November rate, how many rainy days would there be in a year? Cloudy days? Clear days?

D. Rainfall.

22. The rainfall in November equals what part of the rainfall for October? For September?

23. The rainfall for November equals what part of the rainfall for October *and* September?

24. The daily average rainfall for the rainy days in November equals what part of the daily average for the rainy days in October? In September?

25. The daily average rainfall for the cloudy days in November equals what part of the daily average for the cloudy days in October? In September?

26. The daily average rainfall for the month equals what part of the daily average for the rainy days?

E. Dew, Frost, Fogs.

27. The frosty mornings equal what part of the month?

28. The mornings with fog equal what part of the month?

29. The mornings with dew equal what part of the month?

III. RATIO.

A. Temperature.

1. What is the ratio of the average reading of the thermometer for November to the average reading for October? To that for September?

2. What is the ratio of the average reading of the thermometer for November to the average reading for October *and* September?

3. What is the ratio of the greatest range of temperature in November to the greatest range in October? In September?

4. What is the ratio of the lowest reading of the thermometer in November to the lowest reading in October? In September?

5. What is the ratio of the highest reading of the thermometer in November to the highest reading in October? In September?

6. What is the ratio of the average reading of the thermometer on the rainy days in November to the average for the rainy days in October? In September?

7. What is the ratio of the average reading of the thermometer on the clear days in November to the average for the clear days in October? In September?

8. What is the ratio of the average reading of the thermometer for the cloudy days to the average for the clear days in November?

9. What is the ratio of the average reading of the thermometer at which rain fell to that at which snow fell during the month?

B Barometer.

10. What is the ratio of the average hight of the barometer for November to the average for October? For September?

11. What is the ratio of the greatest range in the hight of the barometer in November to the greatest range in October? In September?

12. What is the ratio of the average hight of the barometer for the rainy days to the average hight for the clear days?

13. What is the ratio of the average hight of the barometer on the rainy days to the average hight for the cloudy days without rain?

14. What is the ratio of the average hight of the barometer for the rainy days in November to the average hight for the rainy days in October? In September?

15. What is the ratio of the average hight of the barometer for the clear days in November to the average for the clear days in October? In September?

16. What is the ratio of the average hight of the barometer for the days with less than the average temperature to that with the days having more than the average temperature?

C. Rainy, Cloudy, and Clear Days.

17. What is the ratio of the rainy days in November to the number in October? In September?

18. What is the ratio of cloudy days in November to the number in October? In September?

19. What is the ratio of the clear days in

November to the number in October? In September?

20. What is the ratio of rainy days to clear days in November?

21. What is the ratio of rainy days to cloudy days in November?

22. According to the November ratio, what would be the number of cloudy days in a year? The number of clear days?

23. According to the November ratio, what would be the number of rainy days in a year?

D. Rainfall.

24. What is the ratio of the November rainfall to the rainfall for October? For September?

25. What is the ratio of the daily average rainfall for the rainy days in November to the daily average for the rainy days in October? For September?

26. What is the ratio of the daily average rainfall for the cloudy days in November to the daily average for the cloudy days in October? In September?

27. What is the ratio of the daily average rainfall for the rainy days in November to the daily average for the cloudy days?

28. What is the ratio of the rainfall on the days when the barometer stood below the average hight to the average for the days when it stood above the average hight?

29. What is the ratio of the rainfall on the days when the temperature was below the monthly average to that for the days when the temperature *was above* the average?

E. Dew, Frost, Fog.

30. What is the ratio of the dewy mornings to those with frost?

31. What is the ratio of the clear mornings to those with fogs?

IV. PERCENTAGE.

A. Temperature.

1. The average reading of the thermometer for November equals what per cent of the average reading for October? For September?

2. The average reading of the thermometer for November equals what per cent of the average reading for October *and* September?

3. The greatest range of temperature for November equals what per cent of the greatest range for October? For September?

4. The lowest reading of the thermometer for November equals what per cent of the lowest reading for October? For September?

5. The highest reading of the thermometer for November equals what per cent of the highest reading for October? For September?

6. The average reading of the thermometer for the rainy days equals what per cent of the average reading for the clear days?

7. The average reading of the thermometer for the rainy days in November equals what per cent of the average reading for the rainy days in October? In September?

8. The average reading of the thermometer for the days when it snowed equals what per cent of the average for the rainy days?

B. Barometer.

9. The average hight of the barometer for November equals what per cent of the average hight for October? For September?

10. The greatest range in barometric hight for November equals what per cent of the greatest range for October? For September?

11. The average barometric hight for the rainy days in November equals what per cent of the average for the rainy days in October? In September?

12. The average barometric reading for the clear days in November equals what per cent of the average for the clear days in October? In September?

13. The average reading of the barometer for the rainy days in November equals what per cent of the average for the clear days?

14. The average hight of the barometer for the rainy days in November equals what per cent of the average for the cloudy days?

C. Rainy, Cloudy, and Clear Days.

15. The number of rainy days in November equals what per cent of the number of rainy days in October? In September?

16. The number of clear days in November equals what per cent of the number of clear days in October? In September?

17. The number of cloudy days in November equals what per cent of the number of cloudy days in October? In September?

18. The number of snowy days in November

equals what per cent of the number of cloudy days in November?

19. The number of rainy days in November equals what per cent of the number of cloudy days?

20. The number of rainy days in November, when the barometer was below the monthly average, equals what per cent of the entire number of rainy days?

21. The number of cloudy days without rain in November equals what per cent of the entire number of cloudy days?

22. At the November rate, how many rainy days would there be in a year? Cloudy days? Clear days?

D. Rainfall.

23. The rainfall for November equals what per cent of the rainfall for October? For September?

24. The rainfall for November equals what per cent of the rainfall for October *and* September?

25. At the November rate, what would be the rainfall for a year?

26. The daily average rainfall in November equals what per cent of the daily average for October? For September?

27. The daily average rainfall for the cloudy days in November equals what per cent of that for the cloudy days for October? For September?

28. The daily average rainfall for the rainy days in November equals what per cent of that for the rainy days in October? In September?

29. The daily average rainfall for the month of

November equals what per cent of that for the rainy days?

E. Dew, Frost, Fogs.

30. The mornings with dew equal what per cent of the whole number in the month?

31. The mornings with fog equal what per cent of the whole number in the month?

32. The mornings with frost equal what per cent of the whole number in the month?

METEOROLOGY—AUTUMN MONTHS.

PROBLEMS.

A. Temperature.

1. What is the average reading of the thermometer for the autumn months?

2. What is the greatest range in temperature during autumn?

3. What is the average reading of the thermometer for the rainy days?

4. What is the average reading of the thermometer for the clear days?

5. What is the greatest range of temperature for the rainy days?

6. What is the greatest range of temperature for the clear days?

7. The average reading of the thermometer for the cloudy days equals what part of the average for the clear days?

8. The average reading of the thermometer for the rainy days equals what part of the average for the clear days?

9. What part of the season had passed before the lowest temperature was reached? The highest temperature?

B. Barometer.

10. What is the average hight of the barometer for autumn?

11. What is the greatest barometric range in autumn?

12. The average reading of the barometer for the rainy days equals what part of that for the clear days?

13. The average reading of the barometer for the cloudy days equals what part of the average for the clear days?

14. The average reading of the barometer when the temperature was below the average for the season equals what part of the average reading when the temperature was above?

C. Rainy, Cloudy, and Clear Days.

15. How many rainy days in autumn?

16. At the autumn rate what part of the entire year would be rainy? How many rainy days?

17. At the autumn rate how many cloudy days would there be in a year? Clear days?

18. What part of the entire number of cloudy days were rainy days?

19. What per cent of the cloudy days were without rain or snow?

D. Rainfall.

20. What is the total rainfall for autumn?

21. At the autumn rate what would be the total rainfall for a year?

22. What is the average rainfall for each day in autumn?

23. What is the average rainfall for each rainy day in autumn?

24. What is the average rainfall for each cloudy day in autumn?

25. What part of the rainfall occurred with the barometer below the average hight? Above the average?

26. What part of the rainfall occurred when the temperature was above the average? Below the average?

ASTRONOMY.

VARIATION IN DAY'S LENGTH.

I. WHOLE NUMBERS.

1. What is the variation in the day's length during the first week? During the second? During the third? During the fourth?

2. What is the variation in the day's length during the month?

3. What is the variation in the day's length in the morning during the first week? The second? The third? The fourth? For the entire month?

4. What is the evening variation in the day's length during the first week? The second? The third? The fourth? For the entire month?

5. Which is the greater, and how much, the variation in the day's length during the first week or the variation during the last week?

6. What is the difference between the variation in the day's length in the morning and the variation in the evening during the first week? During the second? During the third? During the fourth? During the entire month?

7. How many degrees on the meridian did the sun pass through during the month? During each week?

8. What was the difference between the length of the day and the length of the night at the beginning of the month? At the end?

9. What is the difference between the length of the last day in November and the length of the first day in September?

10. What is the difference between the variation in the day's length in November and the variation in October? In September?

11. What is the difference between the morning variation in the day's length in November and the morning variation in October? In September?

12. What is the difference between the evening variation in the day's length during November and the evening variation during October? During September?

13. What is the difference between the morning and the evening variation in the day's length during the three months—November, October, and September?

14. What is the difference between the variation in the day's length during the last week in November and the variation during the first week in September?

– 5. What is the difference, in degrees on the meridian, between the movement of the sun in November and that during October? During September?

16. What is the difference, in degrees on the meridian, between the movement of the sun during the last week in November and the movement during the first week in September?

17. What is the difference between the area of the cross-section of the shadow-stick and that of the shadow cast the first week of November? The second week? The third week? The fourth week?

18. What is the difference in area between the shadow cast the first week in November and that cast the last week?

19. What is the difference in area between the shadow cast the first week in September and that of the last week in November?

II. FRACTIONS.

1. The variation in the day's length during the first week in November equals what part of its length at the first of the week? During the second? During the third? During the fourth?

2. The entire variation in the day's length during the month equals what part of the length of the first day of the month?

3. The variation in the day's length, in the morning, during the first week equals what part of the total variation? During the second? During the third? During the fourth?

4. The variation in the day's length, in the evening, during the first week equals what part of the total variation? During the second week? During the third week? During the fourth week?

5. The variation in the day's length, in the morning, during the first week equals what part of the variation in the evening for the same time? The second week? The third week? The fourth week?

6. The variation in the length of the day, in the morning, during the month equals what part of the entire amount of variation?

7. The variation in the length of the day, in the evening, during the month equals what part of the entire amount of variation?

8. The variation in the length of the day, in the morning, during the month equals what part of the variation in the evening?

9. The variation in the day's length during November equals what part of the variation during October? September?

10. The variation in the day's length during the last week in November equals what part of the variation during the first week in September?

11. The variation in the day's length, in the morning, during November equals what part of the variation for the same time in October? In September?

12. The variation in the day's length, in the evening, during November equals what part of the variation for the same time during October? During September?

13. The morning variation in the day's length for the three months, November, October, and September, equals what part of the entire amount of variation for the same time?

14. The evening variation in the day's length for the three months, November, October, and September, equals what part of the entire amount of variation?

15. The morning variation during the three

months, November, October, and September, equals what part of the evening variation for the same time?

16. The number of degrees on the meridian through which the sun passed during November equals what part of the number passed through during the three months, November, October, and September? During October? During September?

17. The area of the cross-section of the shadow-stick equals what part of the area of the shadow cast the first week in November?

18. The area of the shadow cast the first week in November equals what part of the area of the shadow cast the second? The third? The fourth?

19. The area of the shadow cast the first week in September equals what part of the area of the shadow cast the last week in November?

III. RATIO.

1. What is the ratio of the variation in the day's length during the first week to the variation for the entire month? During the second? During the third? During the fourth?

2. What is the ratio of the variation in the day's length during the first week to the variation during the last week?

3. What is the ratio of the morning variation in the day's length during the first week to the entire variation during the week? The second? The third? The fourth?

4. What is the ratio of the evening variation in the day's length during the first week to the entire

variation during the week? The second? The third? The fourth?

5. What is the ratio of the morning variation in the day's length during the first week to the evening variation in the same time? During the second week? During the third week? During the fourth week?

6. What is the ratio of the morning variation in the day's length during the month to the evening variation during the same time?

7. What is the ratio of the morning variation in the day's length during the month to the entire variation during the month?

8. What is the ratio of the evening variation in the day's length during the month to the entire variation during the month?

9. What is the ratio, in length, of November 30th to September 1st?

10. What is the ratio of the variation in the day's length during the last week in November to the variation during first week in September?

11. What is the ratio of the variation in the day's length during November to the variation in September? October?

12. What is the ratio of the morning variation in the day's length during November to the morning variation during October? September?

13. What is the ratio of the evening variation in the day's length during November to the evening variation during October? September?

14. What is the ratio of the morning variation in the day's length during November, October,

and September to the evening variation during the same time?

15. What is the ratio of the movement, in degrees, of the sun on the meridian during November to the movement during October? September?

16. What is the ratio of the movement of the sun, in degrees, on the meridian during the last week in November to the movement during the first week in September?

17. The area of the cross-section of the shadow-stick bears what ratio to the area of the shadow cast the first week in November? The second week? The third week? The fourth week?

18. The area of the shadow cast the first week bears what ratio to the area of the shadow cast the second? The third? The fourth?

19. The area of the shadow cast the first week in September bears what ratio to the area of the shadow cast the last week in November?

IV. PERCENTAGE.

1. What per cent of the day's length at the beginning of the week was lost or gained during the first week? During the second? During the third? During the fourth?

2. What per cent of the day's length at the beginning of the month was gained or lost during the entire month?

3. What per cent of the gain or loss of the day's length during the first week occurred in the morning? During the second week? During the third week? During the fourth week?

4. What per cent of the gain or loss in the day's

length during the first week occurred in the evening? During the second week? During the third week? During the fourth week?

5. The gain or loss in the day's length in the morning during the month equals what per cent of the gain or loss in the evening?

6. The gain or loss in the day's length during the first week equals what per cent of the gain or loss during the last week?

7. The movement, in degrees, of the sun on the meridian during the last week equals what per cent of the movement during the first week?

8. The gain or loss in the day's length during November equals what per cent of the gain or loss during October? September?

9. The gain or loss in the day's length during the last week in November equals what per cent of the gain or loss during the first week in September?

10. The gain or loss in the day's length, in the morning, during November equals what per cent of the gain or loss during October? September?

11. The gain or loss in the day's length, in the evening, during November equals what per cent of the gain or loss for the same time during October? During September?

12. The variation in the length of the day during November equals what per cent of the variation for the three months, November, October, September?

13. The morning variation in the day's length for the three months equals what per cent of the total variation for that time?

14. The number of degrees on the meridian through which the sun passed during November equals what per cent of the number passed through in October? September?

15. The number of degrees on the meridian through which the sun passed during the last two weeks of the month equals what per cent of the number passed through during the first two weeks of September?

16. The number of degrees on the meridian through which the sun passed in October equals what per cent of the number passed through in the three months, November, October, and September?

17. The area of the cross-section of the shadow-stick equals what per cent of the area of the shadow cast the first week in November?

18. The area of the shadow cast by the shadow-stick the first week in November equals what per cent of the area of the shadow cast the second? The third? The fourth?

19. The area of the shadow cast the first week in September equals what per cent of the area of the shadow cast the last week in November?

GEOGRAPHY.

NORTH AMERICA—ZONES AND CLIMATE.

It is the aim, by means of the problems given under this head, to fix in the minds of the pupils definite ideas of those great zones whose boundaries seem to be determined by certain phases of animal and plant life rather than by mathematical lines. The variation of these zones from those dependent upon the mathematical relations of the earth to the sun may be taken as a measure of the effect of the influences of physical features upon astronomical climate. It is a phase of the study of geography which underlies, fundamentally, the study of life distribution (to be considered later) and with this in mind it becomes a subject of surpassing interest.

Guyot gives six *Zones of Vegetation* which are bounded approximately by isothermal lines as follows:

(*a*) North Polar Zone; mean temperature, below 5° Fahr.

(*b*) Arctic Zone; mean temperature, 5° to 30° Fahr.

(*c*) Cold Temperate Zone; mean temperature, 30° to 40° Fahr.

(*d*) Temperate Zone; mean temperature, 40° to 60° Fahr.

(*e*) Warm Temperate Zone; mean temperature, 60° to 72° Fahr.

(*f*) Tropical Zone; mean temperature, 72° to 82° Fahr.

The various areas required in the following problems, when they are not directly given, may be found by adding together the areas of the different political divisions. By these exercises it is intended to lay a foundation for a definite understanding of the relative productiveness of the different regions of the continent.

PROBLEMS.

I. WHOLE NUMBERS.

1. How many square miles in each of the zones given above?

2. Which zone includes the largest area in North America, and how much?

3. Which zone has the smallest area in North America, and how much?

4. Which is larger, and how much, the area included in the two temperate zones or the area of the tropical zone?

5. Which includes a larger area of the continent, and how much, the cold temperate zone or the temperate zone?

6. Which includes the greater area of the continent, and how much, the temperate zone or the warm temperate zone?

7. Which includes the greater area of the continent, and how much, the warm temperate zone or the cold temperate zone?

8. Which includes the greater area of the continent, and how much, the north polar zone or the Arctic zone?

9. Which includes the greater area of the continent, and how much, the Arctic zone or the tropical zone?

10. Which zone has the greatest average width and how much?

11. Which zones have the greater average width, and how much, the temperate zones or the tropical zone?

12. Which zone is the wider, on the average, and how much, the cold temperate zone or the temperate zone?

13. Which zone is the wider, on the average, and how much, the temperate zone or the warm temperate zone?

14. Which is greater in average width, the north polar zone or the Arctic zone?

15. Which is greater in average width, and how much, the Arctic zone or the tropical zone?

16. Which is greater, and how much, the area lying south, or that lying north of the mean annual isotherm of 60°?

17. Which is the greater, and how much, the area lying south, or that lying north of the mean annual isotherm of 50°?

18. Which is the greater, and how much, the area included between 50° and 60° Fahr., or that included between 60° and 70° Fahr.?

19. Which is greater, and how much, the area included between 70° and 80° Fahr., or that included between 60° and 70° Fahr.?

20. Which is greater, and how much, the area included between 40° and 50° Fahr., or that included between 30° and 40° Fahr.?

21. What area, in square miles, lies between the mean July isotherm 60° Fahr. and the mean January isotherm of 60°?

22. What is the average distance that the July isotherm 60° Fahr. lies north of the mean annual isotherm 60° Fahr.?

23. What is the average distance that the January isotherm 60° Fahr. lies south of the mean annual of 60° Fahr.?

24. Which has the greater annual rainfall, and how much, the area east of the Mississippi or the area west, within the United States?

25. Which has the greater rainfall, and how much, the area south of the Ohio River or the area north, within the United States and east of the Mississippi?

26. Which river basin receives the greater depth of rainfall, and how much, the Ohio or the Missouri?

27. Which has the greater depth of rainfall annually, and how much, the Mississippi basin or the St. Lawrence basin?

28. Which receives the greater depth of rainfall annually, and how much, the Atlantic slope or the Pacific slope?

29. Which receives the greater depth of rainfall annually, and how much, the western highland or the eastern highland?

30. Which receives the greater depth of rain-

fall annually, and how much, the eastern or the western division of the Mississippi basin?

31. Which receives the greater depth of rainfall annually, and how much, the area north of the Great Lakes or the area south of them?

II. FRACTIONS.

A. Zones.

1. The area included in the temperate zone equals what part of the area of the continent?

2. The area included in the warm temperate zone equals what part of the area of the continent?

3. The area included in the cold temperate zone equals what part of the area of the continent?

4. The area included in the tropical zone equals what part of the area of the continent?

5. The area included in the Arctic zone equals what part of the area of the continent?

6. The area included in the north polar zone equals what part of the area of the continent?

7. The area included in the three temperate zones equals what part of the area of the continent?

8. The average width of the temperate zone equals what part of the length of the continent?

9. The average width of the warm temperate zone equals what part of the average width of the three temperate zones?

10. The average width of the cold temperate zone equals what part of the average width of the three temperate zones?

11. The average width of the tropical zone equals what part of the average width of the

temperate zones? The warm temperate? The cold temperate?

12. The average width of the Arctic zone equals what part of the length of the continent?

13. The average width of the north polar zone equals what part of the width of the tropical zone?

14. The average width of the Arctic zone equals what part of the average width of the tropical zone?

15. The area of the continent lying south of the mean annual isotherm of 60° Fahr. equals what part of the area of the entire continent? Lying north?

16. The area lying south of the mean annual isotherm of 60° Fahr. equals what part of the area lying north of it?

17. The area lying south of the mean annual isotherm of 50° equals what part of the area of the entire continent?

18. The area included between the mean annual isotherms 60° and 70° Fahr., equals what part of the area between the mean annual isotherms 70° and 80° Fahr.?

19. The area lying south of the mean annual isotherm 70° Fahr. equals what part of the area of the continent?

20. The area lying south of the mean annual isotherm 40° Fahr. equals what part of the area of the continent?

21. The area lying south of the July mean isotherm of 60° Fahr. equals what part of the area of the continent?

22. The area lying south of the January mean

isotherm of 60° Fahr. equals what part of the area of the continent?

23. The area between the July mean isotherm of 60° Fahr. and January mean isotherm of 60° Fahr. equals what part of the continent?

B. Rainfall.

24. The average annual depth of rainfall in the Gulf region equals what part of the average on the Atlantic slope?

25. The average annual depth of rainfall south of the Potomac equals what part of the average north of it, within the United States?

26. The mean annual depth of rainfall in the Ohio basin equals what part of the average in the Missouri basin?

27. The mean annual depth of rainfall in the Ohio basin equals what part of the average in the Gulf region?

28. The mean annual depth of rainfall of the region west of the Mississippi, south of the 36th parallel, equals what part of the average in the same latitude east of the Mississippi?

29. The mean annual depth of rainfall of the eastern highland equals what part of the average of the western highland?

30. The mean annual depth of rainfall between the Rocky Mountains and the Mississippi River equals what part of the average between the Mississippi River and the Alleghany Mountains?

31. The mean annual depth of rainfall north of the Great Lakes equals what part of the average south of them?

III. RATIO.

A. Zones.

1. What is the ratio of the area included in the tropical zone to the area of the entire continent?

2. What is the ratio of the area included in the warm temperate zone to the area of the entire continent?

3. What is the ratio of the area included in the temperate zone to the area of the entire continent?

4. What is the ratio of the area included in the cold temperate zone to the area of the entire continent?

5. What is the ratio of the area included in the Arctic zone to the area of the entire continent?

6. What is the ratio of the area included in the north polar zone to the area of the entire continent?

7. What is the ratio of the area included in the three temperate zones to the area of the entire continent?

8. What is the ratio of the average width of the temperate zone to the length of the continent?

9. What is the ratio of the average width of the tropical zone to the length of the continent?

10. What is the ratio of the average width of the Arctic zone to the length of the continent?

11. What is the ratio of the width of the warm temperate zone to the length of the continent?

12. What is the ratio of the average width of the temperate zone to the length of the continent?

13. What is the ratio of the average width of the cold temperate zone to the length of the continent?

14. What is the ratio of the average width of the north polar zone to the length of the continent?

15. What is the ratio of the area lying south of the mean annual isotherm of 60° Fahr. to the area of the entire continent?

16. What is the ratio of the area lying north of the mean annual isotherm of 60° Fahr. to the area of the entire continent?

17. What is the ratio of the area lying south of the mean annual isotherm 60° Fahr. to the area lying north of the same?

18. What is the ratio of the area lying south of the mean annual isotherm of 60° Fahr. to the area lying south of the mean annual of 50° Fahr.?

19. What is the ratio of the area lying south of the mean annual isotherm of 50° Fahr. to the area of the entire continent?

20. What is the ratio of the area lying south of the mean annual isotherm of 40° Fahr. to the area of the entire continent?

21. What is the ratio of the area lying south of the mean annual isotherm of 50° Fahr. to the area lying south of the mean annual isotherm of 40° Fahr.?

22. What is the ratio of the area lying south of the mean isotherm of 60° Fahr. in July to that lying north of it?

23. What is the ratio of the area lying south of the January mean isotherm of 60° Fahr. to that lying north of it?

24. What is the ratio of the area lying south of the January mean isotherm of 60° Fahr. to that south of the July mean of 60° Fahr.?

B. Rainfall.

25. What is the ratio of the average annual depth of rainfall in the Mississippi basin to the average on the Atlantic slope?

26. What is the ratio of the average annual depth of rainfall in the Mississippi basin to the average on the Pacific slope?

27. What is the ratio of the average annual depth of rainfall west of the Mississippi River to the average east of it?

28. What is the ratio of the average annual depth of rainfall in the Mississippi basin to the average of the Gulf region?

29. What is the ratio of the mean annual depth of rainfall in the St. Lawrence basin to the average in the Ohio basin?

30. What is the ratio of the mean annual depth of rainfall in the Ohio basin to the average of the Missouri basin?

31. What is the ratio of the mean annual depth of rainfall south of the mean isotherm 60° Fahr. to that north of it, within the United States?

32. What is the ratio of the mean depth of rainfall in the United States during winter to the average during the summer?

IV. PERCENTAGE.

A. Zones.

1. The area included in the tropical zone equals what per cent of the area of the continent?

2. The area included in the warm temperate zone equals what per cent of the area of the continent?

3. The area included in the temperate zone equals what per cent of the area of the continent?

4. The area included in the cold temperate zone equals what per cent of the area of the continent?

5. The area included in the Arctic zone equals what per cent of the area of the continent?

6. The area included in the north polar zone equals what per cent of the area of the continent?

7. The area included in the three temperate zones equals what per cent of the area of the continent?

8. The average width of the tropical zone equals what per cent of the length of the continent?

9. The average width of the warm temperate zone equals what per cent of the length of the continent?

10. The average width of the temperate zone equals what per cent of the length of the continent?

11. The average width of the cold temperate zone equals what per cent of the length of the continent?

12. The average width of the Arctic zone equals what per cent of the length of the continent?

13. The average width of the north polar zone equals what per cent of the length of the continent?

14. The average width of the three temperate zones equals what per cent of the length of the continent?

15. The area lying south of the mean annual isotherm of 60° Fahr. equals what per cent of the area of the continent?

16. The area lying south of the mean annual isotherm of 60° Fahr. equals what per cent of the area north of it?

17. The area lying south of the mean annual isotherm of 60° Fahr. equals what per cent of the area lying south of the mean annual isotherm 50° Fahr.?

18. The area lying south of the mean annual isotherm of 50° Fahr. equals what per cent of the area lying south of the mean annual isotherm 40° Fahr.?

19. The area lying south of the mean annual isotherm of 50° degrees Fahr. equals what per cent of the area of the continent?

20. The area lying south of the mean annual isotherm of 40° Fahr. equals what per cent of the area of the continent?

21. The area lying south of the mean July isotherm of 60° Fahr. equals what per cent of the area of the continent?

22. The area lying south of the mean January isotherm of 60° Fahr. equals what per cent of the area of the continent?

23. The area lying south of the mean July isotherm of 60° Fahr. equals what per cent of the area of the continent?

24. The area lying south of the mean January isotherm of 50° Fahr. equals what per cent of the area of the continent?

25. The area lying south of the mean January isotherm of 50° Fahr. equals what per cent of the area lying south of the mean July isotherm of 50° Fahr.?

B. Rainfall.

26. The mean annual depth of rainfall on the Atlantic slope equals what per cent of the average in the Mississippi basin?

27. The mean annual depth of rainfall in the Gulf States equals what per cent of the average in the Mississippi basin?

28. The mean annual depth of rainfall on the Pacific slope equals what per cent of the average in the Mississippi basin?

29. The mean annual depth of rainfall west of the Mississippi River equals what per cent of the average east of it?

30. The mean annual depth of rainfall east of the Mississippi River and north of the Ohio River equals what per cent of that south of the Ohio River?

31. The mean annual depth of rainfall in the Missouri basin equals what per cent of the average of the Ohio basin?

32. The mean annual depth of rainfall in the St. Lawrence basin equals what per cent of the average in the Ohio basin?

33. The mean annual depth of rainfall in the St. Lawrence basin equals what per cent of the average in the Gulf States?

34. The mean annual depth of rainfall in the

St. Lawrence basin equals what per cent of the average in the Missouri basin?

35. The mean annual depth of rainfall in the St. Lawrence basin equals what per cent of the average on the Pacific slope?